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UPPER MISSISSIPPI RIVER SYSTEM ENVIRONMENTAL MANAGEMENT PROGRAM DEFINITE PROJECT REPORT (R-6F) WITH INTEGRATED ENVIRONMENTAL ASSESSMENT

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PEORIA LAKE ENHANCEMENT

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TECHNICAL APPENDICES

JUNE 1990

US Army Corps of Engineers
Rock Island District

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PEORIA POOL
ILLINOIS WATERWAY

~~90 10 01 087~~

DEPARTMENT OF THE ARMY
ROCK ISLAND DISTRICT, CORPS OF ENGINEERS
CLOCK TOWER BUILDING—P.O. BOX 2004
ROCK ISLAND, ILLINOIS 61204-2004

REPLY TO
ATTENTION OF:

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UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
DEFINITE PROJECT REPORT
WITH INTEGRATED ENVIRONMENTAL ASSESSMENT (R-6F)

PEORIA LAKE ENHANCEMENT
PEORIA POOL, ILLINOIS WATERWAY, RIVER MILES 178.5 TO 181
STATE OF ILLINOIS

TECHNICAL APPENDICES

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STATE OF ILLINOIS

TECHNICAL APPENDICES

HYDRODYNAMIC ANALYSIS OF PEORIA LAKE
FOR ENVIRONMENTAL MANAGEMENT PROGRAM

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APPENDIX E

UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
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APPENDIX E
HYDRODYNAMIC ANALYSIS OF PEORIA LAKE FOR ENVIRONMENTAL MANAGEMENT PROGRAM

E-1. INTRODUCTION.

a. Project Description.

The 1988 topography and bathymetry data of the Peoria Lake region were used to establish the base conditions for the study area. Peoria Lake is about 1.6 miles wide from its left bank to the Illinois River navigation channel at latitude 1,540,000 N (plate E-1). Normal pool elevation of Peoria Lake is 440 feet. The area of concern is between Illinois River miles 177 and 182. The depths in this portion of Peoria Lake range from 0.5 foot to 3.0 feet. In the study area, the widest part of the Illinois River (1,100 feet) is approximately 700 feet upstream of river mile 181 near the Illinois and East River confluence. The navigation channel is the most narrow (275 feet) approximately 3,100 feet downstream of river mile 177. The navigation channel reaches depths of 20 feet or more about 600 feet downstream of the Atchison, Topeka, & Santa Fe Bridge, approximately 900 feet downstream of river mile 179 and approximately 600 feet downstream of river mile 177. The average navigation channel depths range from 15 to 20 feet.

The Illinois and East River confluence is about 400 feet upstream of Illinois River mile 181 (plate E-1). The East River ranges in width from 200 to 250 feet and is approximately 6,000 feet long from the confluence to the silt plug. The river has a maximum depth of about 9 feet near the confluence and gradually becomes more shallow as it approaches the silt plug. The average depth in the upper end of the river is about 5 feet, decreasing to about 3 feet in the lower end. The East River contains an upper and lower cut (plate E-2) which provide direct access to Peoria Lake. The upper cut is approximately 85 feet wide, with maximum depth in the 8- to 9-foot range. The lower cut is approximately 95 feet wide, with maximum depth in the 5- to 6-foot range. The 200-foot-wide silt plug is located about 230 feet downstream of the lower cut and extends approximately 2,000 feet downstream at elevation 441 feet, 1 foot above the normal lake elevation. The silt plug is populated with willow trees.

The proposed construction has three main hydraulic components: (1) the proposed barrier island and adjacent borrow area; (2) the East River silt plug removal and lower cut fill; and (3) the East River outlet channel, plates E-2 and 3. Cross-sectional details of the plans are found on plate E-4. The hydraulic evaluation of the proposed Forested Wetland Management Area is presented in Appendix F.

Aerial photographs of Peoria Lake (4-30-88), sounding maps of Peoria Lake (4-16-88), and maps of the Illinois and Des Plaines Rivers (1902-1904) were used to lay out the topography of the lake area. Township maps of Marshall and Woodford Counties were used to determine property in the area currently owned by the State of Illinois (plate E-5). Climatography of the United States (Series 82) was used to determine wind roses which factored into the alignment of the proposed barrier island (plate E-1).

Illinois River soundings were unavailable in one reach of the navigation channel. Missing data extends 185 feet upstream to 1,760 feet downstream of river mile 180. The soundings in this area were linearly interpolated to produce continuous contour lines.

b. Hydraulic Assessment Objectives.

The general hydraulic assessment objectives of the Peoria Lake study were to predict and evaluate the impact of the proposed island on current patterns, particularly in the adjacent navigation channel; to predict sedimentation characteristics in the adjacent borrow area; and to determine the effects of the removal of the silt plug, located in the lower East River. Specific objectives were to forecast changes to the bed shear stress, to forecast changes to current patterns, and to ensure that the presence of the island does not raise the water surface profile more than the District's allowable swell-head. The two primary areas of interest were the immediate vicinity of the island and the East and Illinois River confluences, both upstream and downstream. The model testing program consists of a base test, which models the currently existing conditions, and three plan tests.

E-2. MODEL DEVELOPMENT.

a. Description.

The 2-D Numerical Model study was conducted using the TABS-2 modeling system (Thomas and McAnally, 1985). This system, which consists of more than 40 computer programs to perform modeling and related tasks, provides 2-D solutions to open channel problems using finite element techniques. The major modeling component used in this study was RMA-2V, which calculates 2-D depth averaged flows. The other programs in the system perform digitizing, mesh generation, data management, graphical display, output analysis, and model interfacing tasks. Although TABS-2 may be used to model unsteady flow, in this study only steady-state conditions were simulated. Input data requirements for the hydrodynamic model, RMA-2V, include channel geometry, Manning's roughness coefficients, turbulent exchange coefficients, and boundary flow conditions.

b. Grid Generation.

A finite element grid was developed to simulate the Peoria Lake area. The first step in the process of the grid generation was to draw a composite map of the area. The model limits then were laid out on the working map and the enclosed area was divided into regions. The regions were digitized and a file was created using state plane coordinates. This file contains all the digitized points, defines the regions, and divides each into a specified number of divisions depending on desired network resolution. The boundaries of each region and the desired element density information were used to calculate the node and element numbers and to develop the element-nodal point connection table.

The Peoria Lake grid for the base and plan 1 tests contains 2,301 submerged elements at a water surface elevation of 451 feet (figure E-1). The grid for plans 2 and 3 contains 1,861 elements due to the lower water surface elevation used and the subsequent drying of elements above a 441.5 foot pool. The element resolution is the highest in the areas of greatest interest. These areas include the Illinois River, the East River, the silt plug, the proposed barrier island and adjacent borrow area, and the East River outlet channel. An expanded view of Chillicothe Island and East River for the base and plan 1 tests is shown on figure E-2. The expanded view of the proposed island and adjacent borrow area is shown on figure E-3. The navigation channel of the Illinois River and the East River are represented in the grid in a three-element wide configuration, i.e., a trapezoidal shape. The upper and lower cuts on the left bank of the East river are two elements wide, i.e., "V"-shaped, in the base and plan 1 configurations. The configuration differences in the two grids are the realignment of the outlet channel and the change in the upper cut to a three-element-wide opening to accomplish requirements for plans 2 and 3, shown in figure E-4.

The currently existing elevations were used in the base test. The elevations and Manning's n-values were changed to model all plan conditions in both grids.

E-3. BASE TEST.

a. Description.

The existing conditions in the Peoria Lake area as described in the introduction are the base test. The inflow boundary of the model is located at the Atchison, Topeka, & Santa Fe Bridge, 725 feet downstream of Illinois River mile 182, and spans the width of the Illinois River. It is labeled as section I-I on figure E-1. These inflow boundary nodes are specified with U-velocity and V-velocity vectors. The outflow boundary is located 3,700 feet downstream from river mile 177, labeled as section O-O

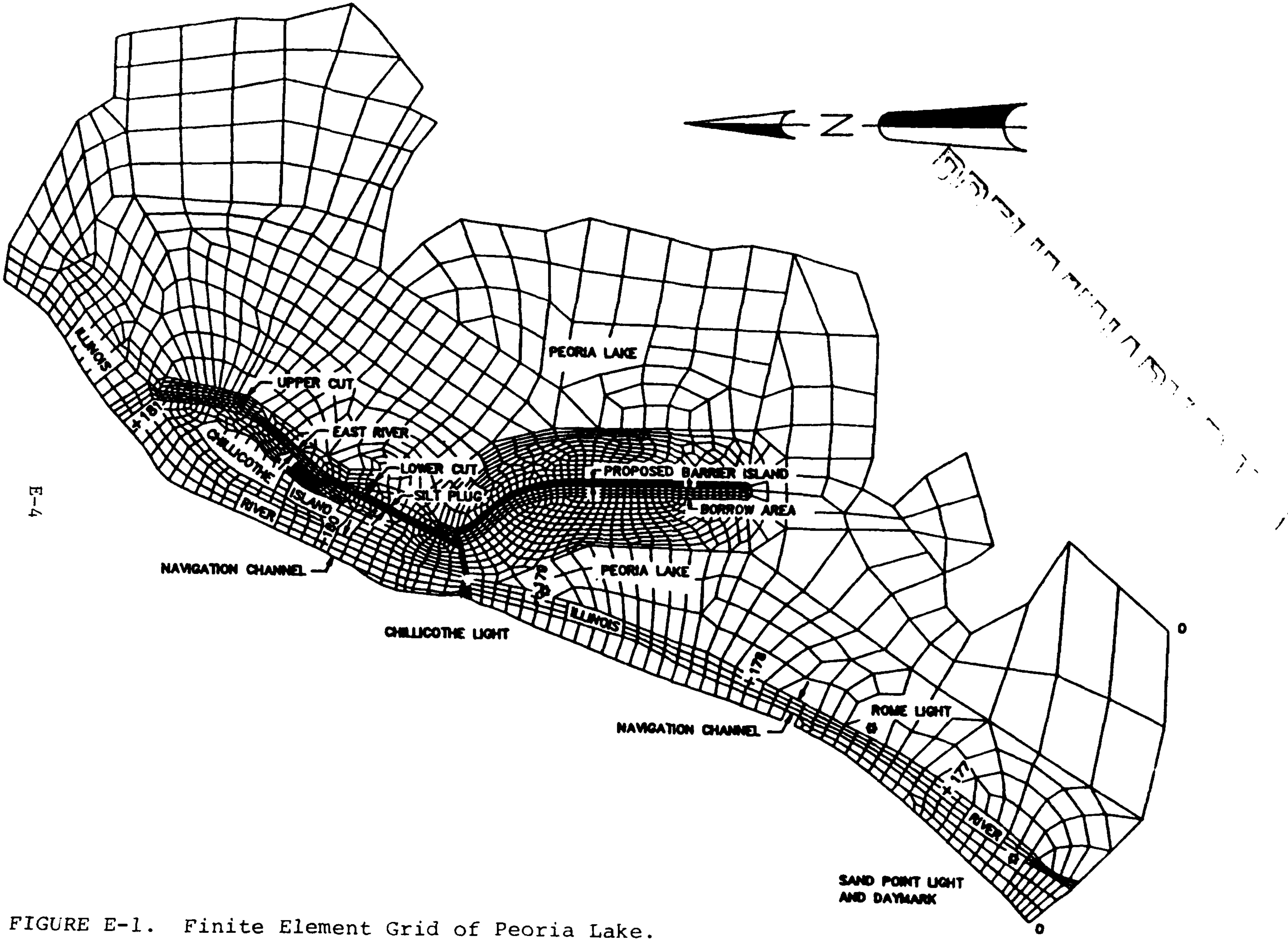


FIGURE E-1. Finite Element Grid of Peoria Lake.

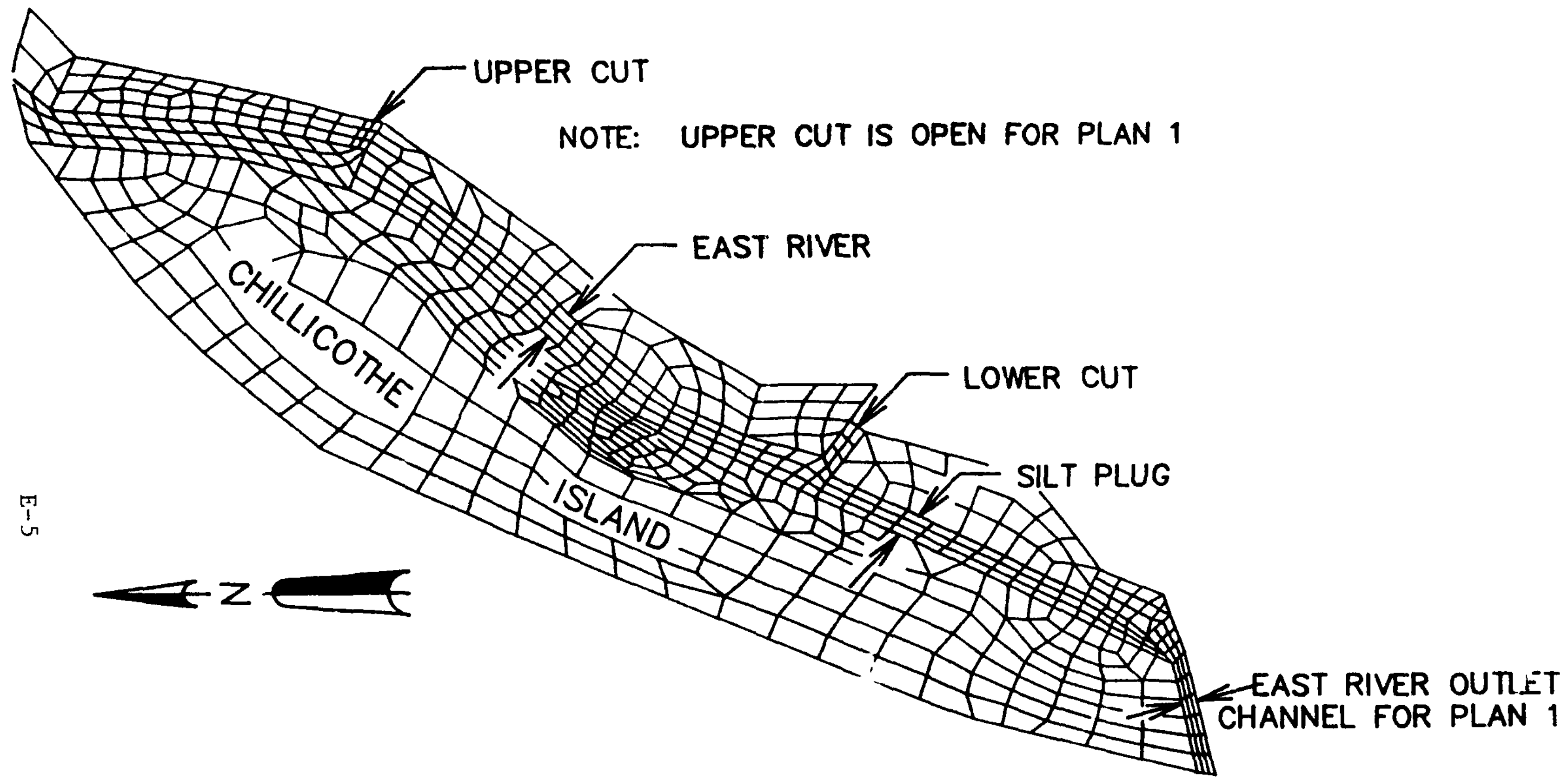


FIGURE E-2. Finite Element Grid of Chillicothe Island and East River for Base Conditions and Plan 1

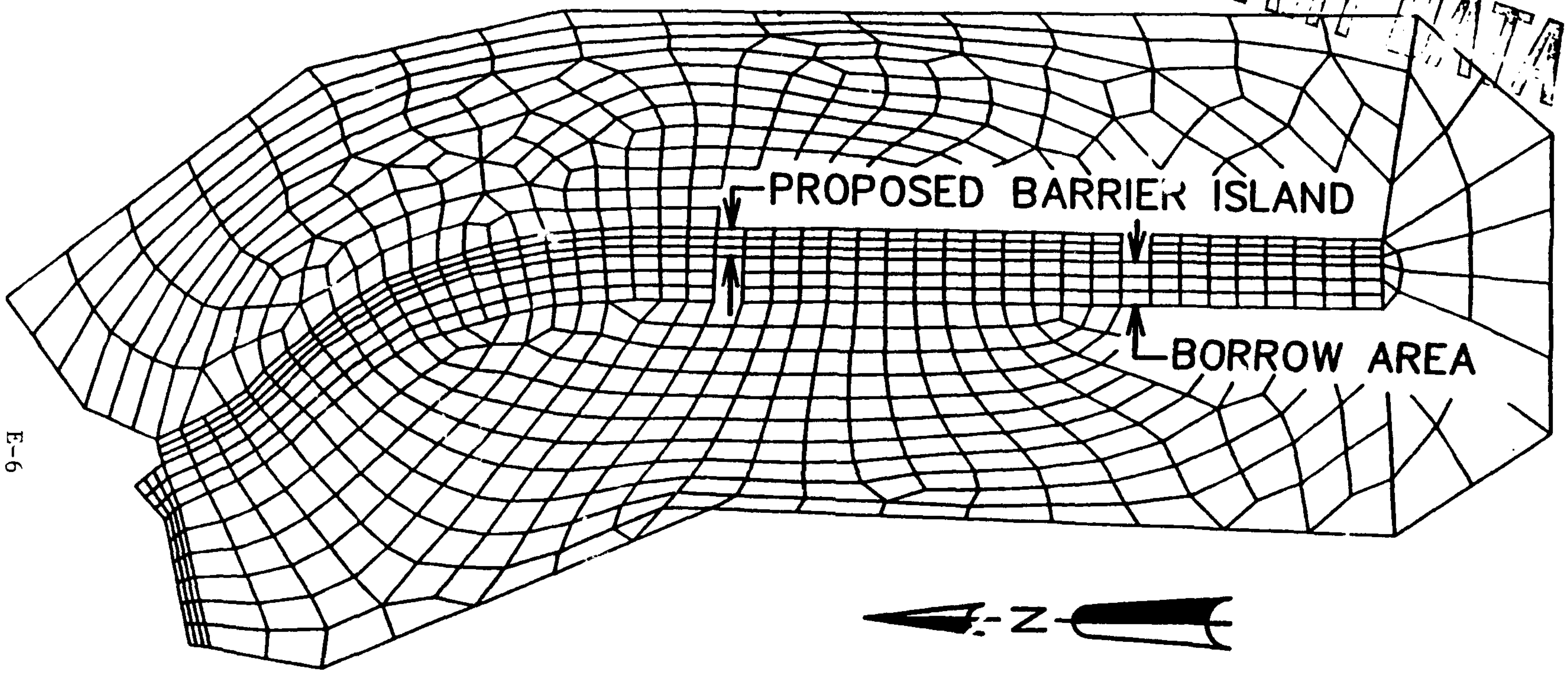


FIGURE E-3. Finite Element Grid of Proposed Barrier Island and Adjacent Borrow Area for Base Conditions and Plan 1

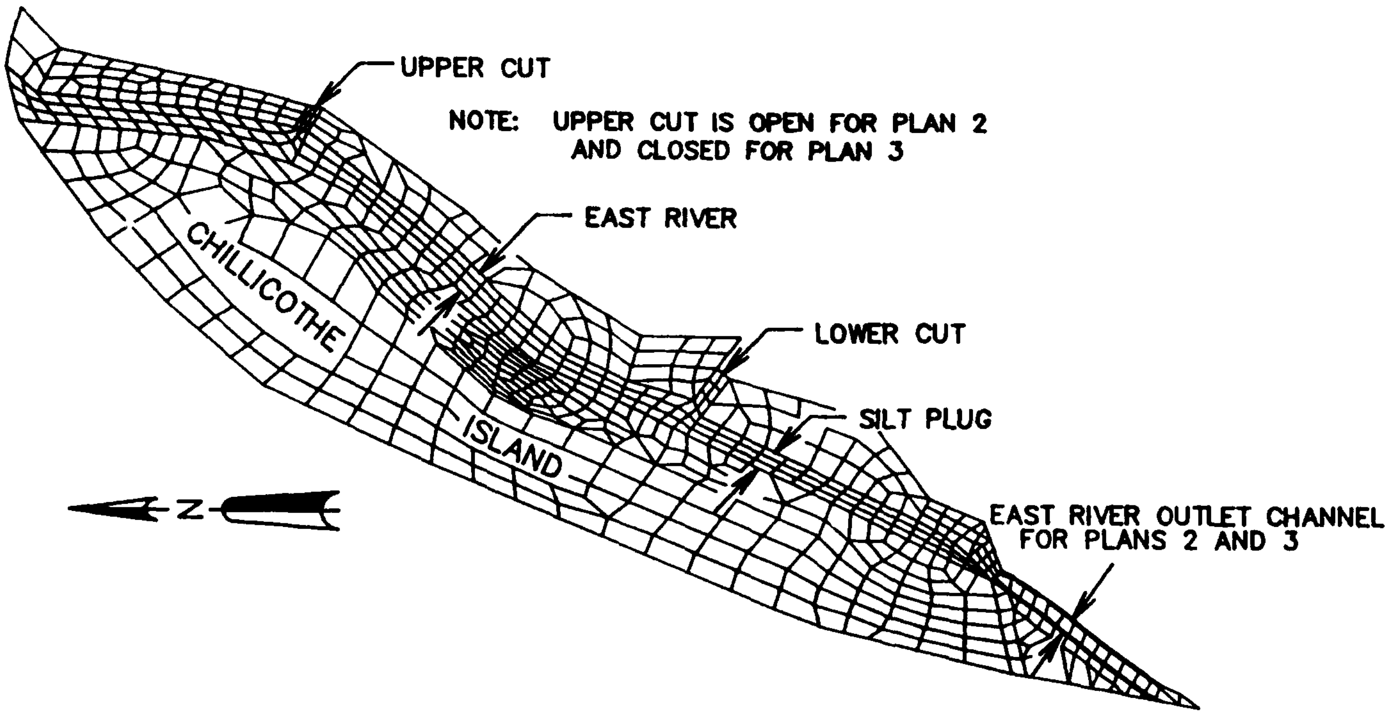


FIGURE E-4. Finite Element Grid of Chillicothe Island and East River for Plans 2 and 3 on figure E-1. The outflow boundary nodes are defined by water surface elevations.

The 2-year flood event was chosen for this study for two reasons. One consideration was the likelihood of event occurrence. The 2-year flood has a 50-percent probability of being equaled or exceeded during a water year; therefore, it is often associated with the dominant, channel forming processes in a river. The other factor is that the 2-year flood in the proposed island area does not create a depth that would cause the complete dissipation of the effects of the proposed island. The 2-year flood discharge is 62,000 cubic feet per second (cfs), the downstream water surface elevation is 451 feet, and the proposed island crest elevation is 446 feet.

The Atchison, Topeka, & Santa Fe Bridge was chosen as the inflow boundary because the Illinois River discharge is confined within this cross-sectional area. This site is located far enough upstream to allow for full development of flow characteristics before entering the area of interest.

A roughness coefficient of 0.080 was used to model vegetated areas that are overtopped at a 62,000 cfs discharge, and a 0.025 roughness coefficient was used for river and lake bed areas.

b. Results.

The computed results of the base test lack formal confirmation due to the unavailability of comparable data. The only means of verification was to compare the water surface profile supplied by the Rock Island District with the computed base test water surface profile. The base test water surface elevations show little head loss, 0.04 foot, from river miles 180 to 178. The Rock Island water surface profile supported the model findings of negligible water surface slope in the Peoria Lake area.

The high density of points along the proposed alignment of the barrier island and silt plug removal site reflect the present elevations and n-values. The elevation of the barrier island and cuts are described in the section concerning the plan 1 test.

The computed velocities from the base test range from near zero to the average inflow boundary velocity of 4.87 feet per second (fps), as shown on figure E-5. At the Illinois and East river confluence, the velocities decrease to a range of 2.0 to 2.5 fps. The velocities continue to decline in the East River from 2.5 fps at the confluence to 1.25 fps at the upper cut. Velocities in the vicinity of the silt plug are less than 0.25 fps. Proposed island area velocities range from 0.5 fps to 0.75 fps. In the Illinois River navigation channel adjacent to the proposed island, the velocities range from 0.75 fps to 1.5 fps.

General current patterns are shown in figure E-6. Figures E-7 and 8 are expanded views in the vicinity of the confluence and the proposed barrier island, respectively. Note the rather strong current leaving the

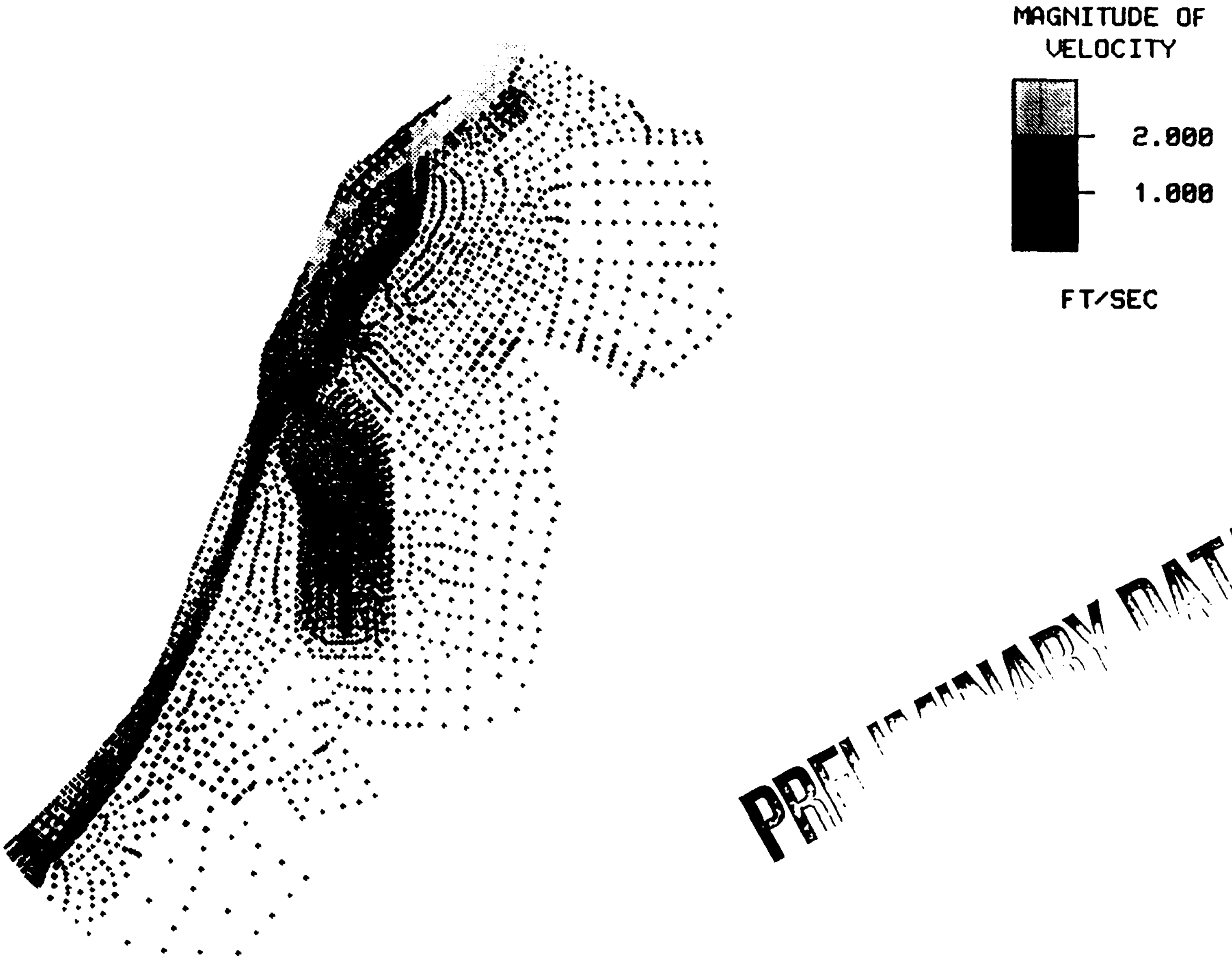
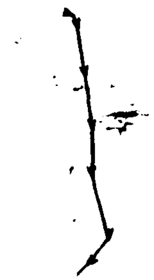


FIGURE E-5. Computed Velocities of Base Condition



VELOCITY VECTOR

SCALE 4.0

4.0 (FPS)

EXCEEDS SCALE LIMIT

XS - 3000.56 FT/IN

YS - 3536.51 FT/IN

PRE

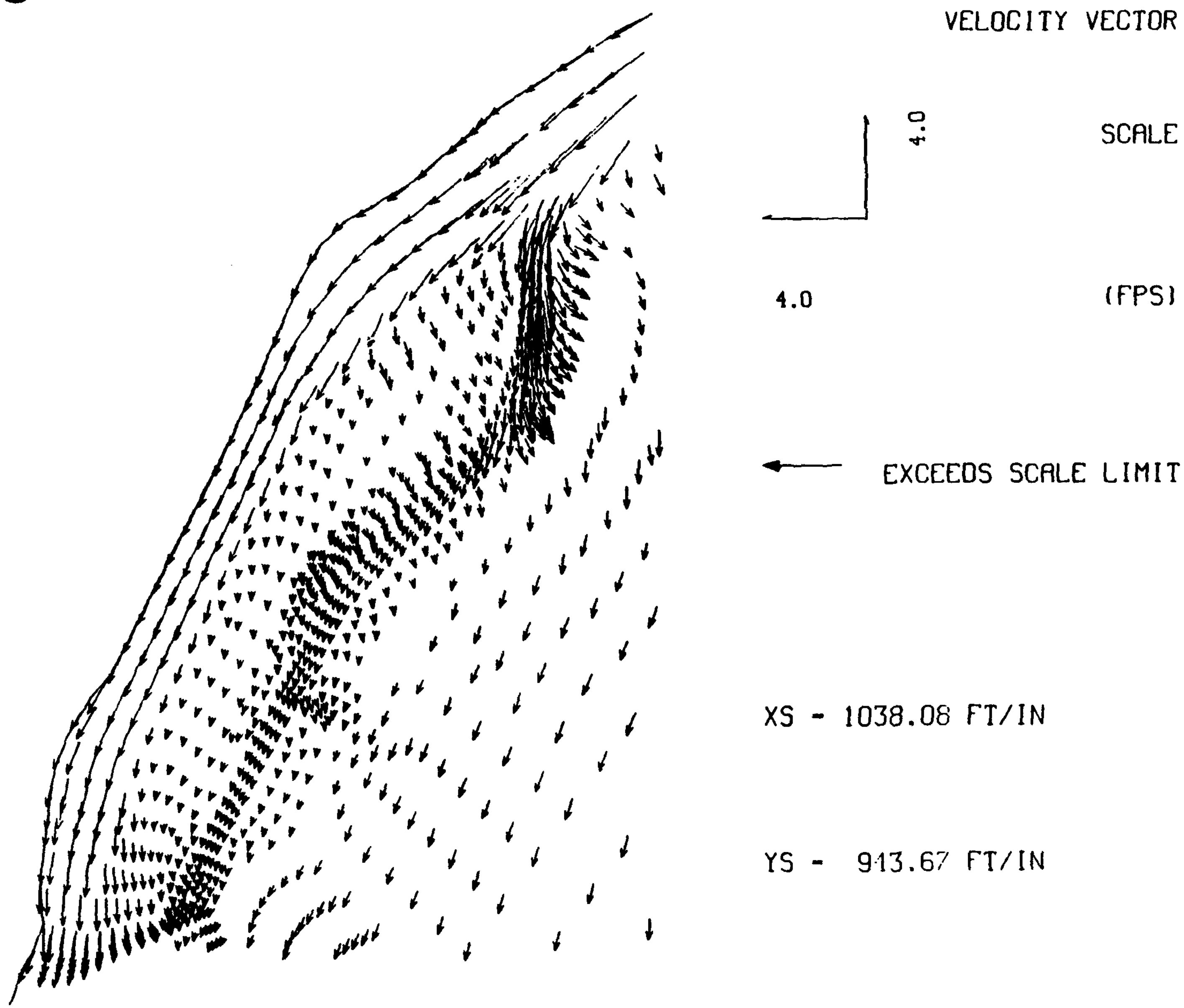


FIGURE E-7. Base Condition Current Patterns for Chillicothe Island and East River

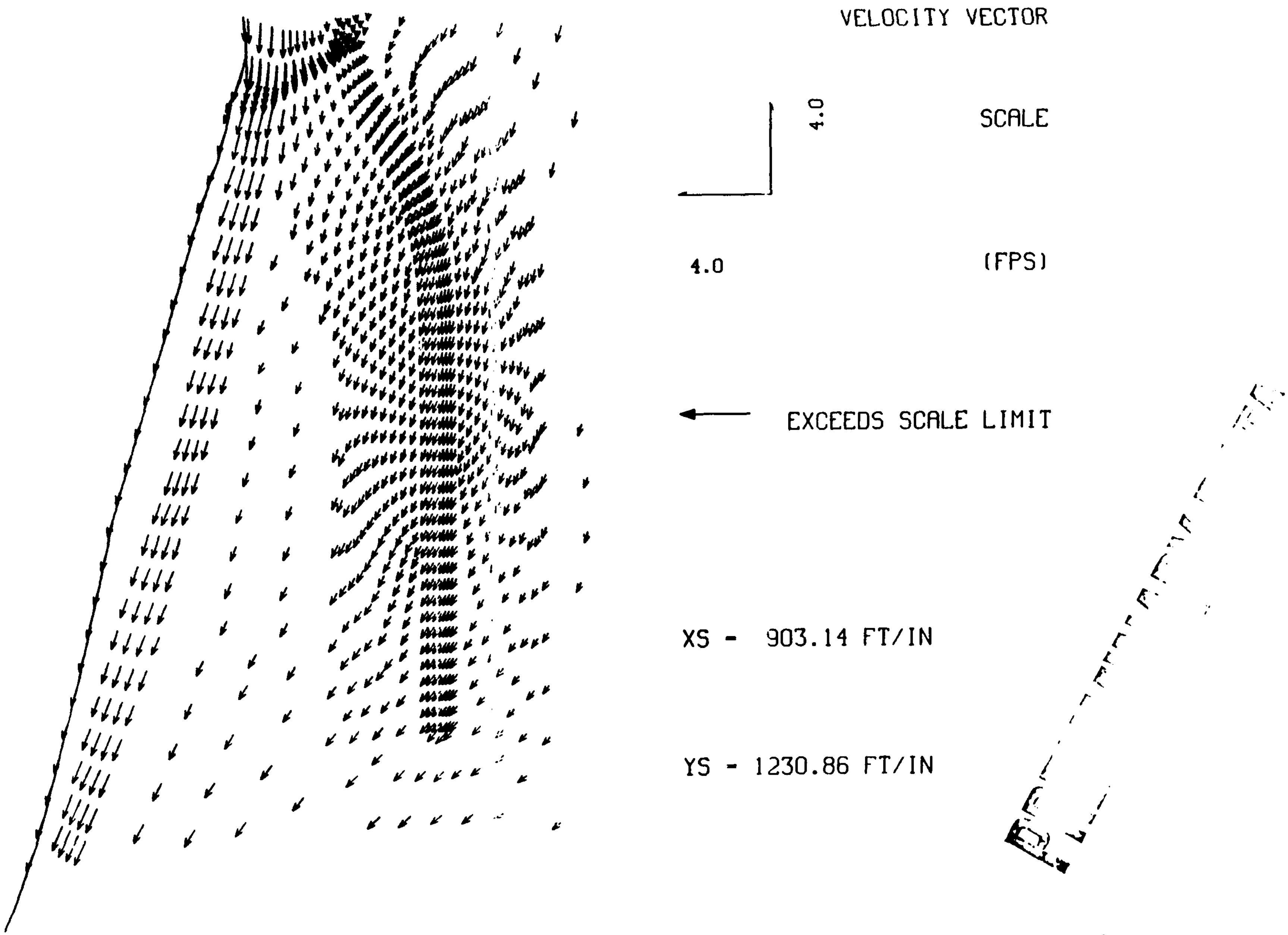


FIGURE E-8. Base Condition Current Patterns for Proposed Barrier Island and Adjacent Borrow Area navigation channel in preference for the East River and upper Peoria Lake (figure E-7). In the vicinity of the proposed barrier island (figure E-8) current patterns are generally down lake or slightly toward the navigation channel.

Bed shear stresses shown in figure E-9 indicate the energy level in the flow field and can be used to predict zones of deposition. Values less than 0.02 pounds per square foot (psf) are expected to allow the deposition of coarse silts. For values greater than 0.02 psf, the coarse silts will remain suspended in the water column.

These deposition threshold coefficients were not determined from field data; they are based on coefficients from two sources: (1) Lanes diagram for allowable non-eroding velocities as reproduced in Appendix A, Figure A-20, Design of Small Dams, United States Department of the Interior, Bureau of Reclamation, Third Edition, 1987; and (2) the comparison of the grain shear stress versus the critical shear stress for erosion using Shields criteria as reproduced in figure 2.44 of Sedimentation Engineering, Manual 54 of The American Society of Civil Engineers, 345 East 47th Street, New York, New York, 1975. The smallest grain size shown on Lane's diagram is 0.1 mm, and that size is not eroded at shear stresses below 0.02 psf. That shear stress converts to an average velocity of 1.19 fps in the 2-foot-deep water and to 1.43 fps where water is 6 feet deep. However, the flow velocities at the silt plug cut are less than 0.25 fps, and that converts to grain shear stresses of 0.0003 and 0.0002 psf for the 2-foot and the 6-foot-deep water, respectively.

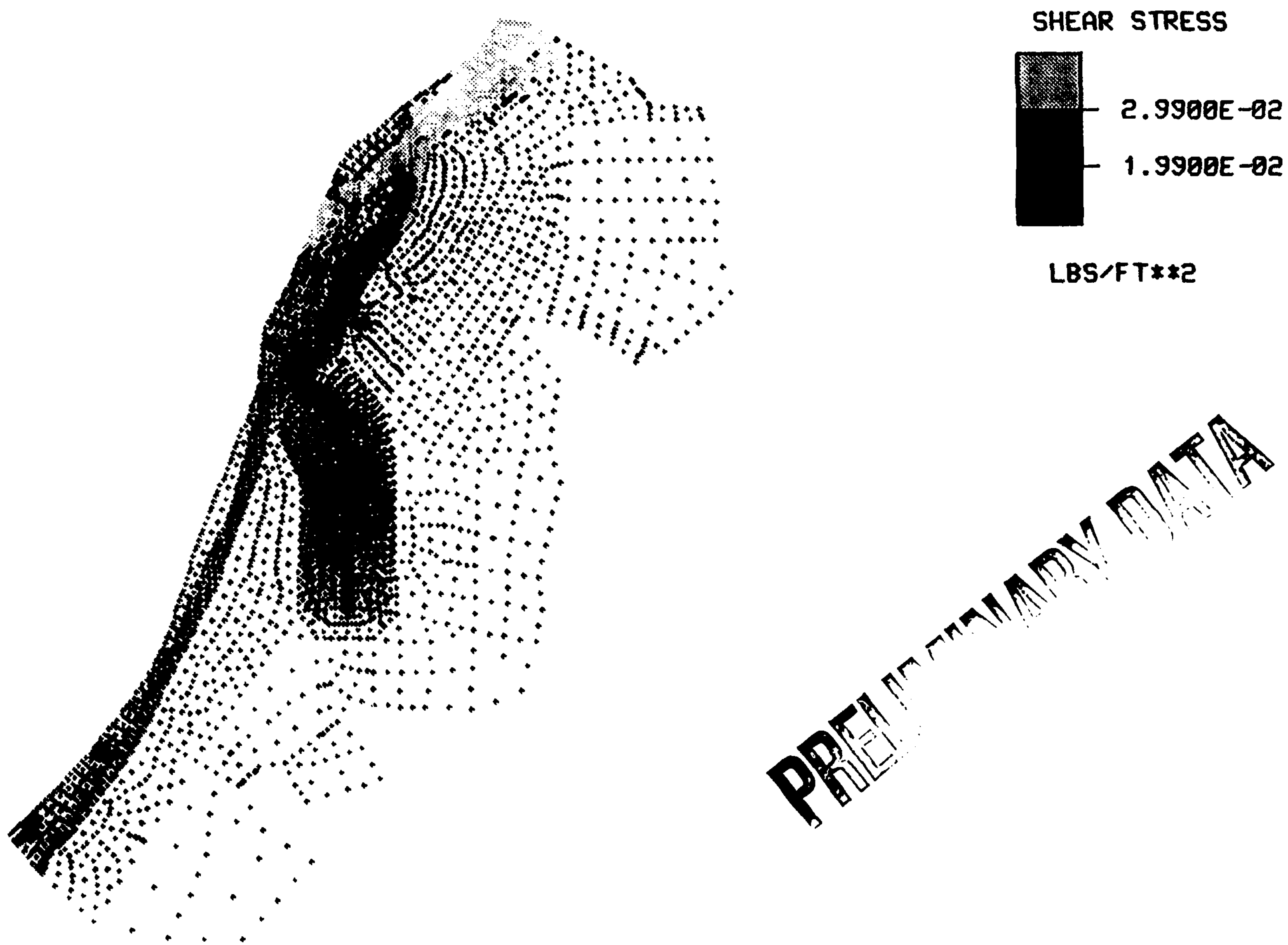
Only the navigation channel upstream from Illinois River mile 180 and the upper end of the East River show values sufficient to prevent deposition of the silts and clays. The lower end of the East River, where the silt plug has formed, and the location of the barrier island have bed shear stresses less than 0.01 psf.

E-4. PLAN 1 TEST.

a. Description.

The plan 1 test is the implementation of three main hydraulics components: (1) the proposed barrier island and adjacent borrow area; (2) the East River silt plug removal and lower cut fill; and (3) the East River outlet channel (plate E-2). The proposed island is 1.3 miles long. The northern end of the island will be 1,000 feet due east of the Illinois River navigation channel at a point 3,300 feet downstream of river mile 180. The following considerations were the basis for the design of the proposed island:

-- Geotechnical constraints are based on information shown on plate E-6. The timber and brush line from the 1903 topography shows a natural ridge existing between Goose Lake and Mullins Slough. Soil borings PL-89-1, -2, -4, -5, and -6 show that the foundation along the ridge



PRELIMINARY DATA

FIGURE E-9. Computed Bed Shear Stresses of Base Condition.

would be adequate to support the proposed barrier island, Appendix G, figures G-2 and 3.

-- The protection provided by the proposed island from excessive wave energy due to dominant wind directions, as shown by wind roses in plate E-1, and fetch lengths.

The island will have a 50-foot-wide crest at elevation 446 feet and 1 on 6 side slopes (plate E-4). The trapezoidal-shaped borrow area will exist adjacent to the island on the west side and will be 224 feet wide. The 1 on 4 left side slope and 1 on 3 right side slope will extend from the bottom elevation of 426 feet to the consolidated bed elevation of 438 feet.

The East River silt plug, as described in the introduction, will be excavated, and the dredged material will be deposited on both the right and left banks of the East River adjacent to the excavation site. The resulting trapezoidal-shaped channel will be 143 feet wide. The excavation site will have a bottom elevation of 433 feet, a top elevation of 441 feet, and 1 on 3 side slopes. Elevation 433 (7 feet from flat pool) is based on a maintained water depth from flat pool of 4 feet plus an additional sedimentation allowance of 3 feet. The maintained water depth of 4 feet was selected based on approximately 4 feet of existing water depth in the upper, stable side channel area. The excavation begins at the lower cut (plate E-2) and extends into the borrow area west of the proposed island, i.e., the excavation for the silt plug and proposed island is continuous in plan 1. The proposed dredged material disposal sites will be 122 feet wide. The sites will have a 50-foot-wide crest of elevation 447 feet, a bottom elevation of 441 feet, and 1 on 6 side slopes. The lower cut, described in the introduction, also will be used as a fill site, bringing it up to elevation 447 feet. The hydraulic calculations indicate no significant effect on current patterns due to the lower cut being filled or left open. However, a longer design life for the silt plug excavation is anticipated if the lower cut is filled.

The East River outlet channel (plate E-2) is approximately 1,300 feet long and 125 feet wide (plate E-4). The trapezoidal-shaped channel will have a bottom elevation of 433 feet, a top elevation of 438 feet, and 1 on 3 side slopes. The channel will have left and right adjacent dredged material placement sites. These 92-foot-wide placement sites will have 50-foot-wide crests of elevation 441.5 feet, a bottom elevation of 438 feet, and 1 on 6 side slopes. The outlet channel runs into the Illinois River navigation channel approximately 3,500 feet downstream of river mile 180.

A roughness coefficient of 0.080 was used to model vegetated areas that are overtopped at a 62,000 cfs discharge. For the plan conditions, the roughness coefficient in the silt plug excavation site was lowered to 0.025 due to tree removal.

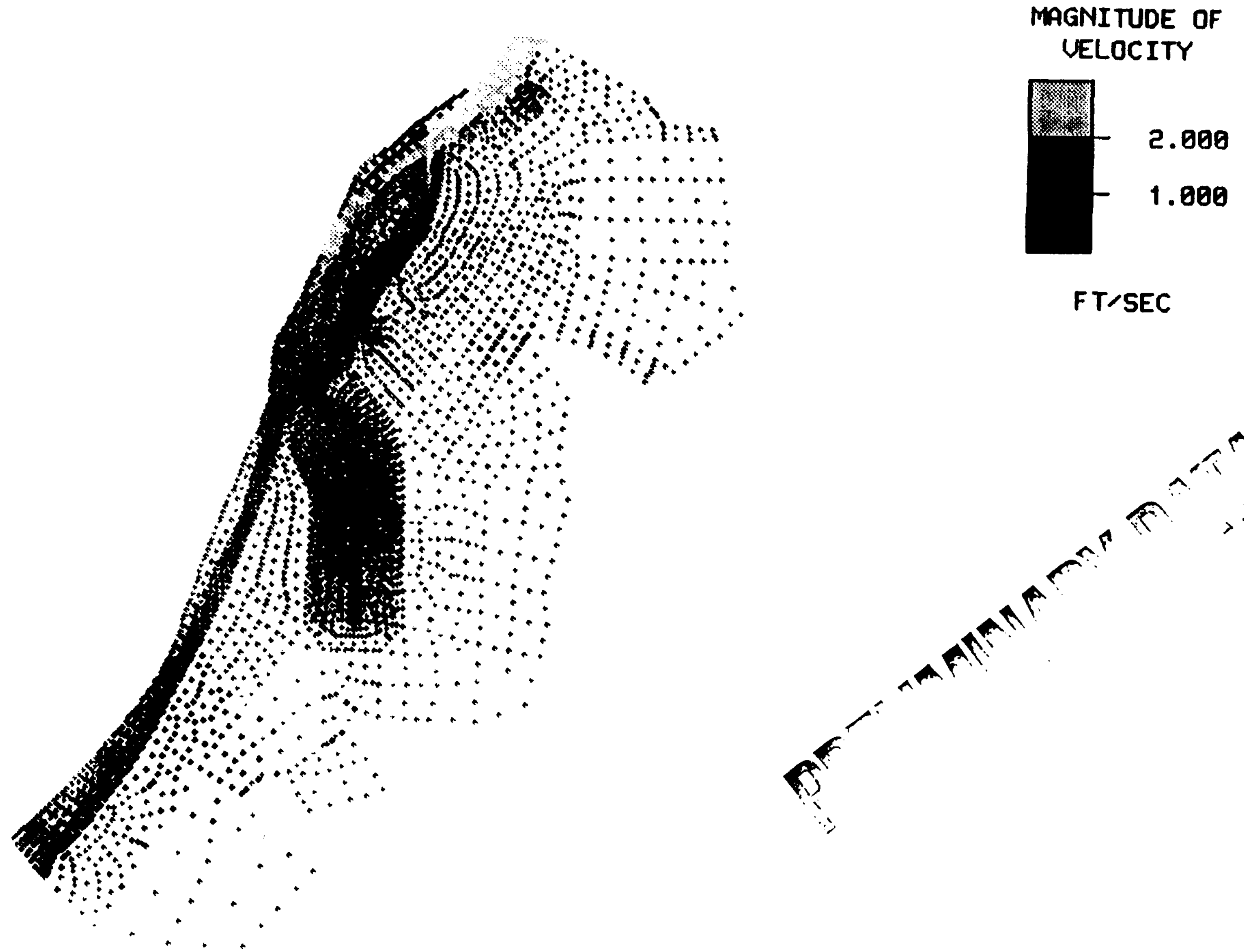


FIGURE E-10. Computed Velocities of Plan 1 Conditions.

b. Results.

The resulting plan 1 test velocities (figure E-10) range from near zero to the average inflow boundary velocity of 4.87 fps. The calculated velocities for the base and plan 1 tests are comparable at the Illinois and East River confluence and in the East River down to the silt plug area. The plan 1 velocities in the silt plug area range from 0.25 fps to 0.50 fps.

The velocities across the upstream end of the proposed island crest range from 1.0 fps to 1.5 fps. Mid-island crest velocities range from 0.5 fps to 1.0 fps. The velocities across the downstream end of the island range from 0.5 fps to 1.25 fps. The velocities in the Illinois River navigation channel adjacent to the proposed island range from 0.75 fps to 1.5 fps.

The overall current pattern is shown in figure E-11. Figures E-12 and 13 are expanded views of the East River and Chillicothe Island, and the proposed barrier island, respectively. The two areas anticipated to have altered current patterns were the upper confluence with the East River and the upper end of the barrier island. The figures indicate that the presence of the proposed island will have no discernable impact on current patterns in the Illinois River navigation channel in these areas. The current patterns also indicate that no significant change is expected in sediment patterns adjacent to privately owned land.

There is no discernable difference, when compared to the base test, in the bed shear stresses calculated for the Illinois River navigation channel from the upper boundary of the model to the upper end of the proposed barrier island (figure E-14). There is a slight shear stress reduction in the vicinity of Illinois River mile 179. These base test values are already less than 0.02; therefore, this decrease is not expected to be significant. The energy generated by passing tows may contribute to maintaining existing channel depths and not the energy in the flow field, alone.

Of particular interest is the cut proposed for the silt plug. The bed shear stress (figure E-14) showed no significant increase as a result of this feature. Even with the lower cut plugged, as in our model, and vegetation cleared across the excavated plug, the bed shear stresses remained less than 0.01 psf. This indicates a long-term problem leading to the reformation of the silt plug. The time required is expected to be controlled by hydrology. Reformation could happen quickly if runoff is abnormally high. The best timeframe indication is the period which elapsed during the formation of the present silt plug.

The presence of the barrier island has no discernable impact on the bed shear stresses except for those occurring across the crest itself. The shear stresses across the upstream quarter of the island crest are about 0.03 psf (figure E-14). The cohesive nature of the construction materials to be used is expected to withstand these shear stresses. The proposed island borrow area and the East River outlet channel are expected to fill at the historical rate characteristic of Peoria Lake (figure E-21).

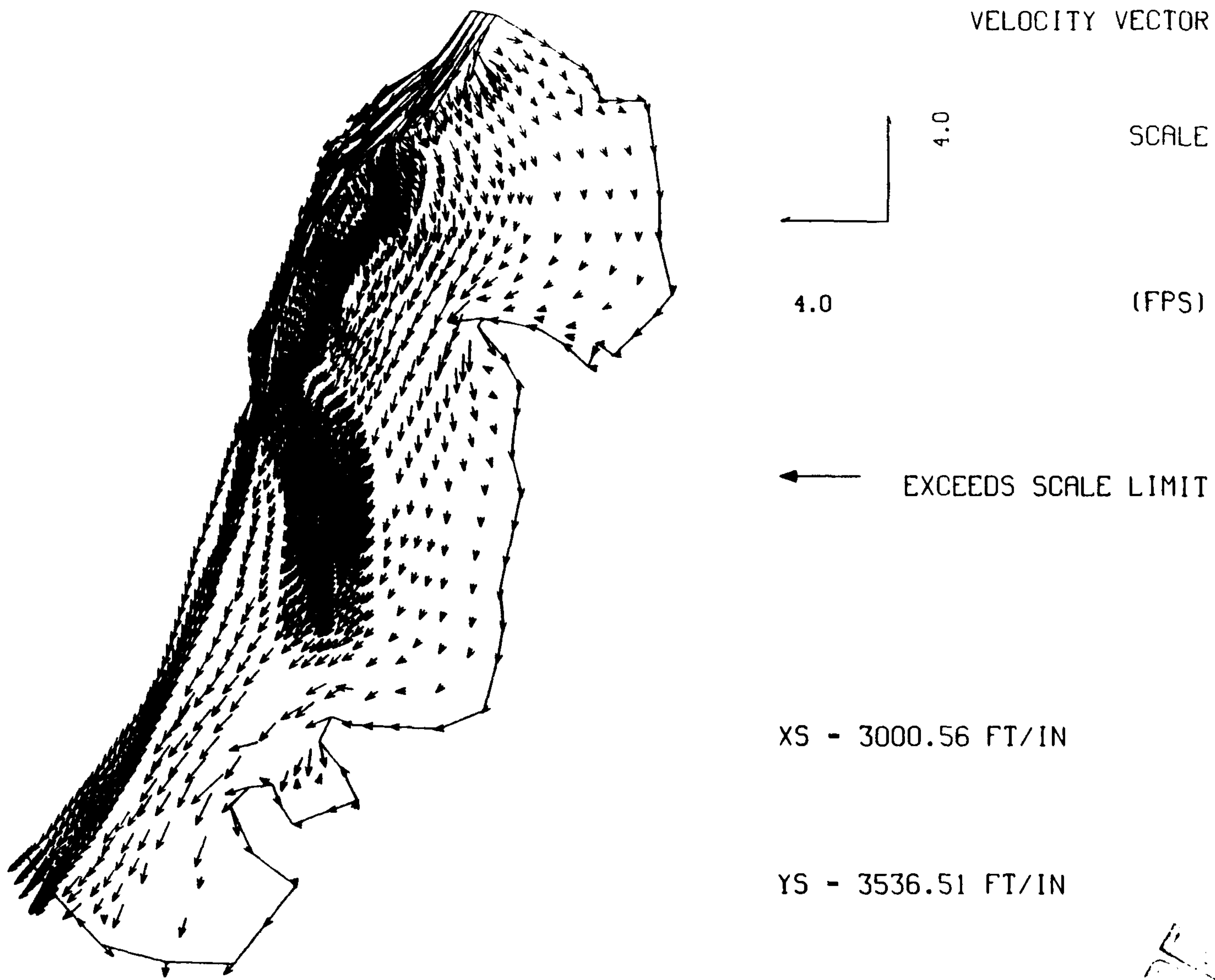


FIGURE E-11. Plan 1 Condition Current Patterns

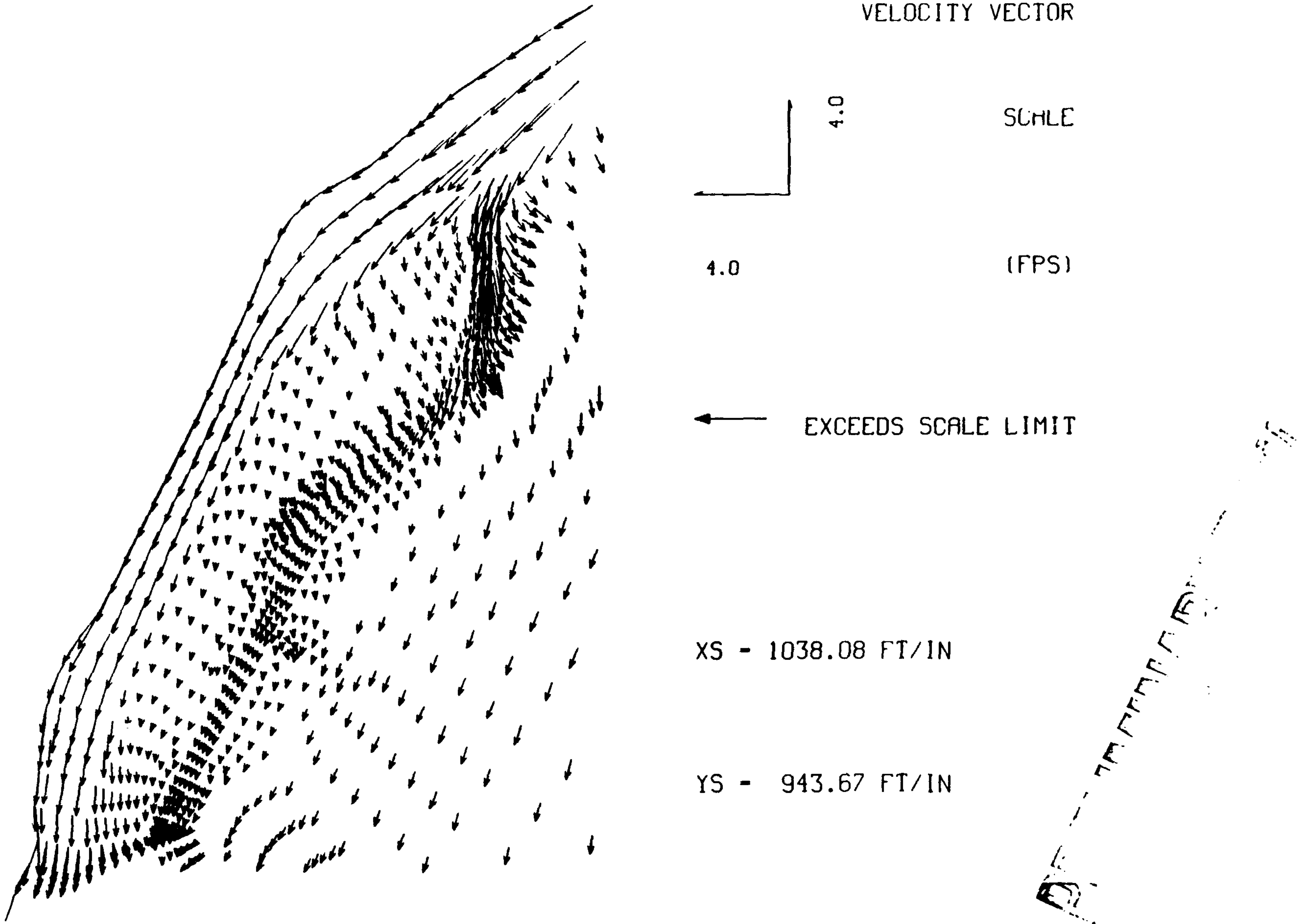


FIGURE E-12. Plan 1 Condition Current Patterns for Chillicothe Island and East River.

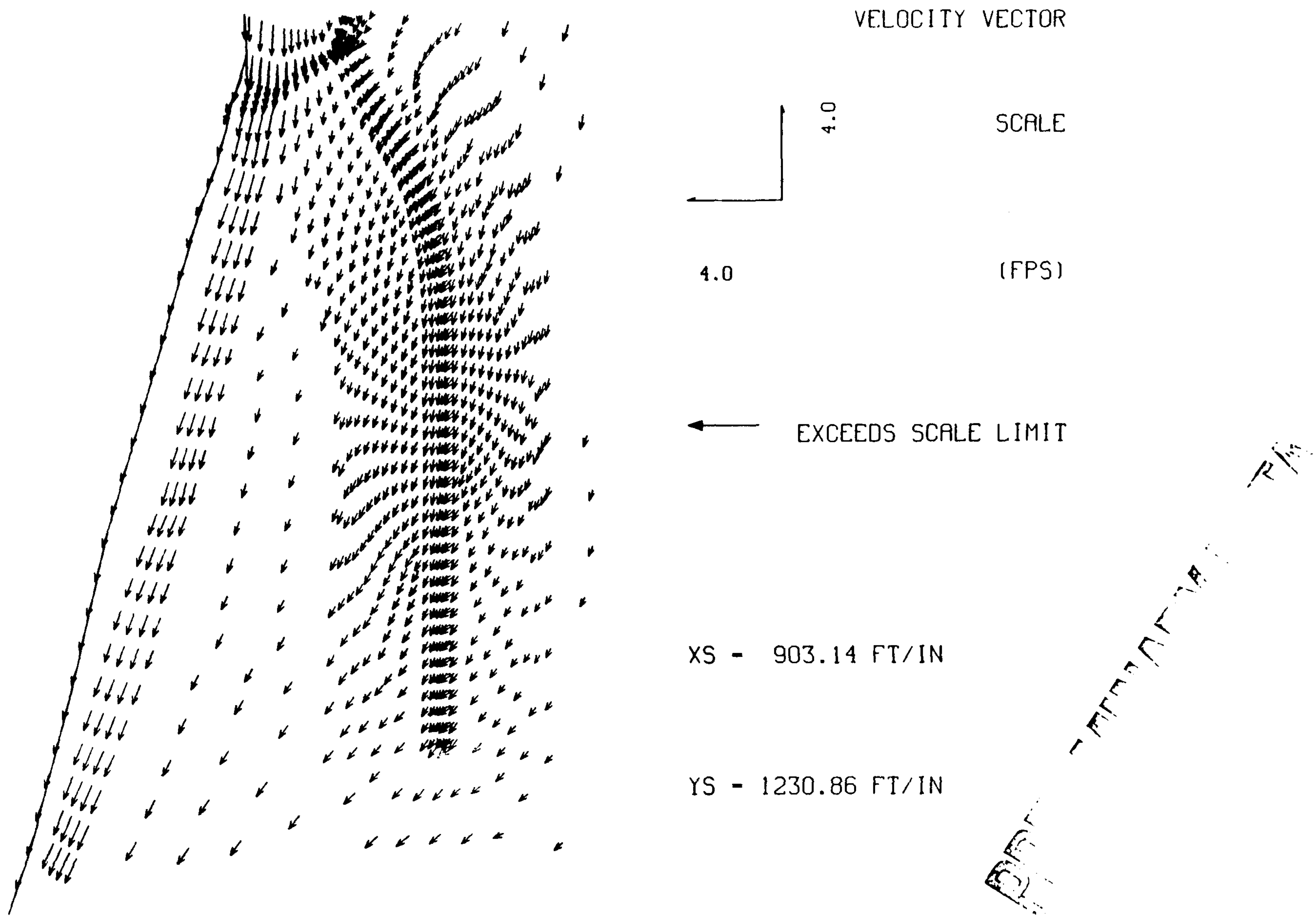


FIGURE E-13. Plan 1 Condition Current Patterns for Proposed Barrier Island and Adjacent Borrow Area.

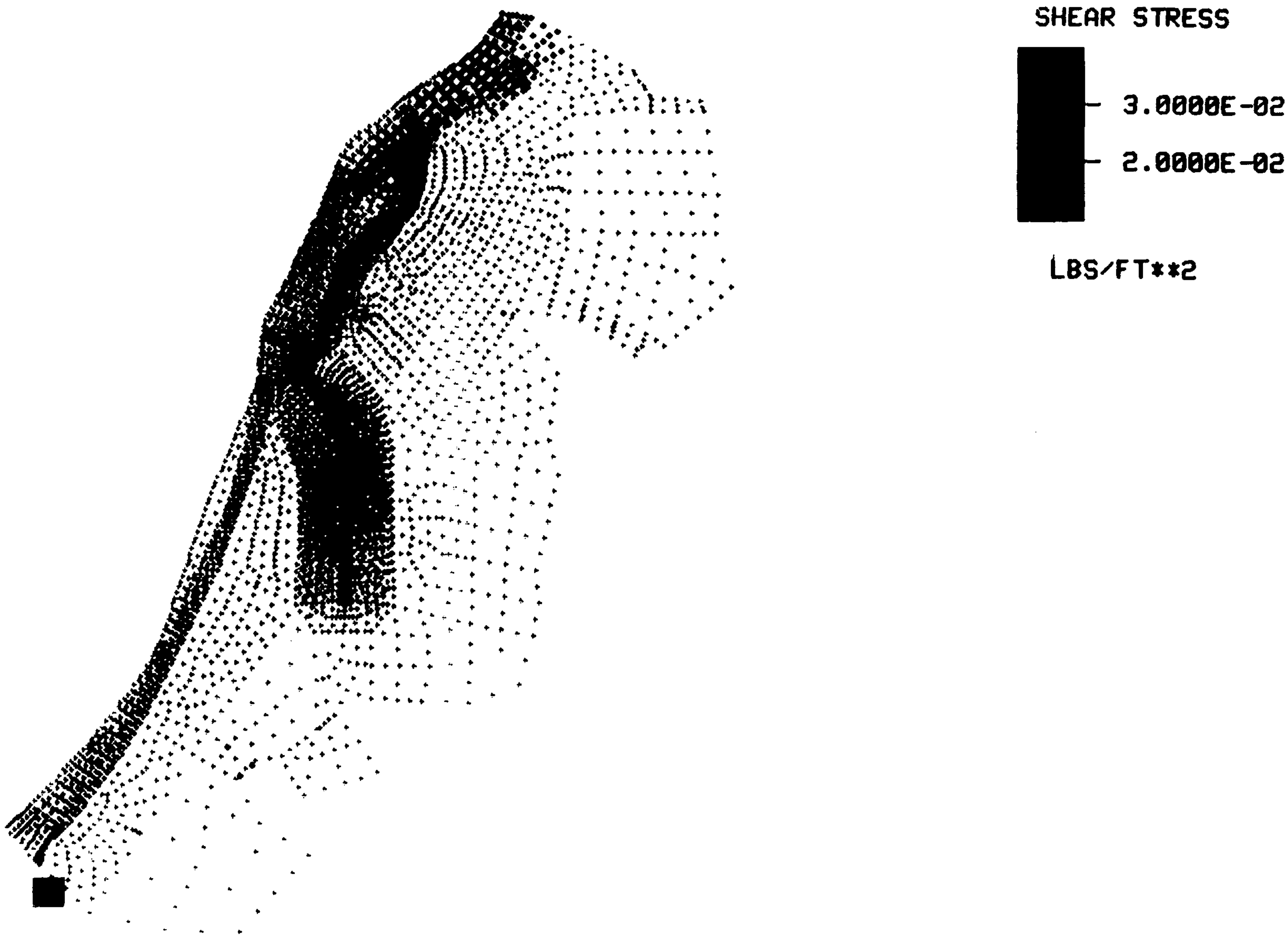


FIGURE E-14. Computed Bed Shear Stresses of Plan 1 Condition.

Peoria Lake is so shallow for several miles downstream of the proposed barrier island that the height of wind waves is expected to be limited by the depth (plate E-1). The equation for fully developed waves in shallow water is:

$d_b / H_b = 1.28$ (Munk 1949)
d_b = breaking depth
H_b = breaking height

Using this relationship, and using an average water depth of 2 feet, the maximum wave height in this portion of Peoria Lake would be about 1.6 feet. Waves from passing tows are expected to be a more significant energy source, especially at the upper end of the proposed island. Using graphs found in the Shore Protection Manual, Vols. I and II, (1948), the runup for breaking height waves was estimated to be about 5 feet. In cases where values were too small to find on the graphs, the minimum value was used. The stability of Chillicothe Island indicates that the proposed barrier island also will be stable due to the use of similar construction materials.

The presence of the proposed barrier island had no impact on the water surface profile. Under the 2-year flood condition, the proposed island acted as a submerged weir for which all hydraulic control was eliminated due to high water surface elevation.

E-5. PLAN 2 TEST.

a. Description.

The plan 2 test is the implementation of the same three main hydraulic components as plan 1 and the same conditions in the upper and lower cuts, i.e., the upper cut is open and the lower is closed. There are three differences in these plans: (1) the East River outlet is rotated approximately 40 degrees counter clockwise from the plan 1 location and is increased in length to about 2,290 feet as shown on plate E-3; (2) the silt plug excavation in the lower East River is not continuous with the borrow area adjacent to the proposed barrier island; and (3) the model discharge is reduced to 14,000 cfs with a water surface elevation of 441.5 feet in order to produce bank full conditions in the East River. The channel dimensions shown on plate E-4 remain the same for all three plans. A Manning's n-value of 0.025, the value used for the river and lake beds, was used throughout the entire grid.

b. Results.

The average inflow boundary velocity for plan 2 is 1.8 fps. The resulting plan 2 velocities (figure E-15) range from near zero to a maximum velocity of 3.4 fps, which occurs in the upper cut. The velocities in the upper cut range from 1.6 fps to the maximum velocity. The range of velocities in the upper cut area is significantly higher than those shown in this same area for the 2-year flood tests. The flow on the east side of the upper cut

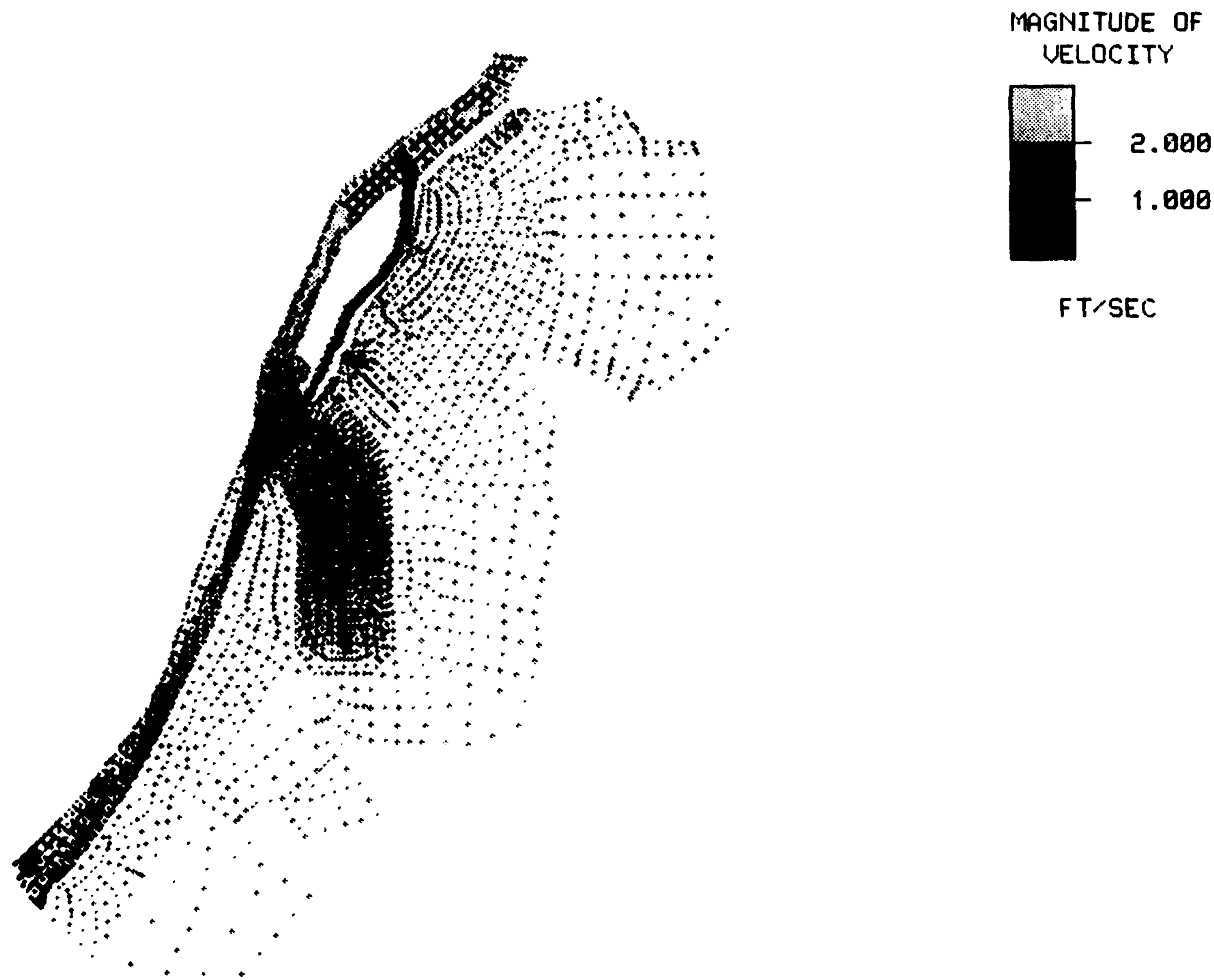


FIGURE E-15. Computed Velocities of Plan 2 Conditions.

immediately loses energy and the velocities drop to about 1.0 fps. The velocities in the Illinois and East River confluence range from 1.0 to 1.6 fps. The velocities increase to a range of 1.8 to 2.0 fps just upstream of the upper cut. The velocities decrease to a range of 0.6 to 1.3 in the reach between the upper and lower cut. The silt plug excavation channel has velocities ranging from 0.6 to 0.8 fps, which is about twice the velocities of plan 1 test in this area. Velocities in the East River outlet range from 0.5 to 0.8 fps. The cross-current influence of the Illinois River navigation channel on the East River outlet tends to overpower the effects of the flow pattern out of the East River (figure E-16). This could indicate a tendency towards deposition in the outlet channel.

The highest velocities in the Illinois River navigation channel are located next to Chillicothe Island upstream of river mile 180. These velocities range from 1.8 to 2.7 fps and extend downstream to river mile 179.

Velocities on the west side of the proposed island are 0.5 fps on the upper end, 0.6 fps in the middle, and 0.3 on the lower end. Velocities on the east side of the island are less than 0.1 fps.

Bed shear in the upper cut ranges from 0.02 to 0.15 psf (figure E-17); therefore, no deposition of sand, silt, or clay sediment is expected. The East River, downstream of the upper cut through the outlet channel, has bed shear values less than 0.02 psf; therefore, the sand and silt particles are expected to settle out of the water column.

E-6. PLAN 3 TEST.

a. Description.

Plan 3 is the same as plan 2 in all aspects except for the upper cut which is reduced to a 30-foot width and raised to a 435-foot elevation. The cross-sectional area is reduced to a minimum while still allowing room for river traffic.

b. Results.

The average inflow boundary velocity for plan 3 is 1.8 fps (figure E-18). The velocities range from near zero up to 4.5 fps in the upper cut. This increase in maximum velocity in the upper cut is due to the decrease in cross-sectional area. From the Illinois and East River confluence to the upper cut, the velocities range from 0.9 to 1.4 fps. In the reach between the upper and lower cuts, the velocities range from 0.8 to 1.6 fps. The velocities downstream of the lower cut through the silt plug excavation channel range from 0.8 to 1.1 fps. Overall, the velocities upstream of the upper cut are lower in plan 3 than in plan 2, and the velocities downstream of the upper cut are higher in plan 3 as more of the flow from the navigation channel is forced down the East River. The rate of flow in the other areas of concern for plan 3 are comparable to those in plan 2.

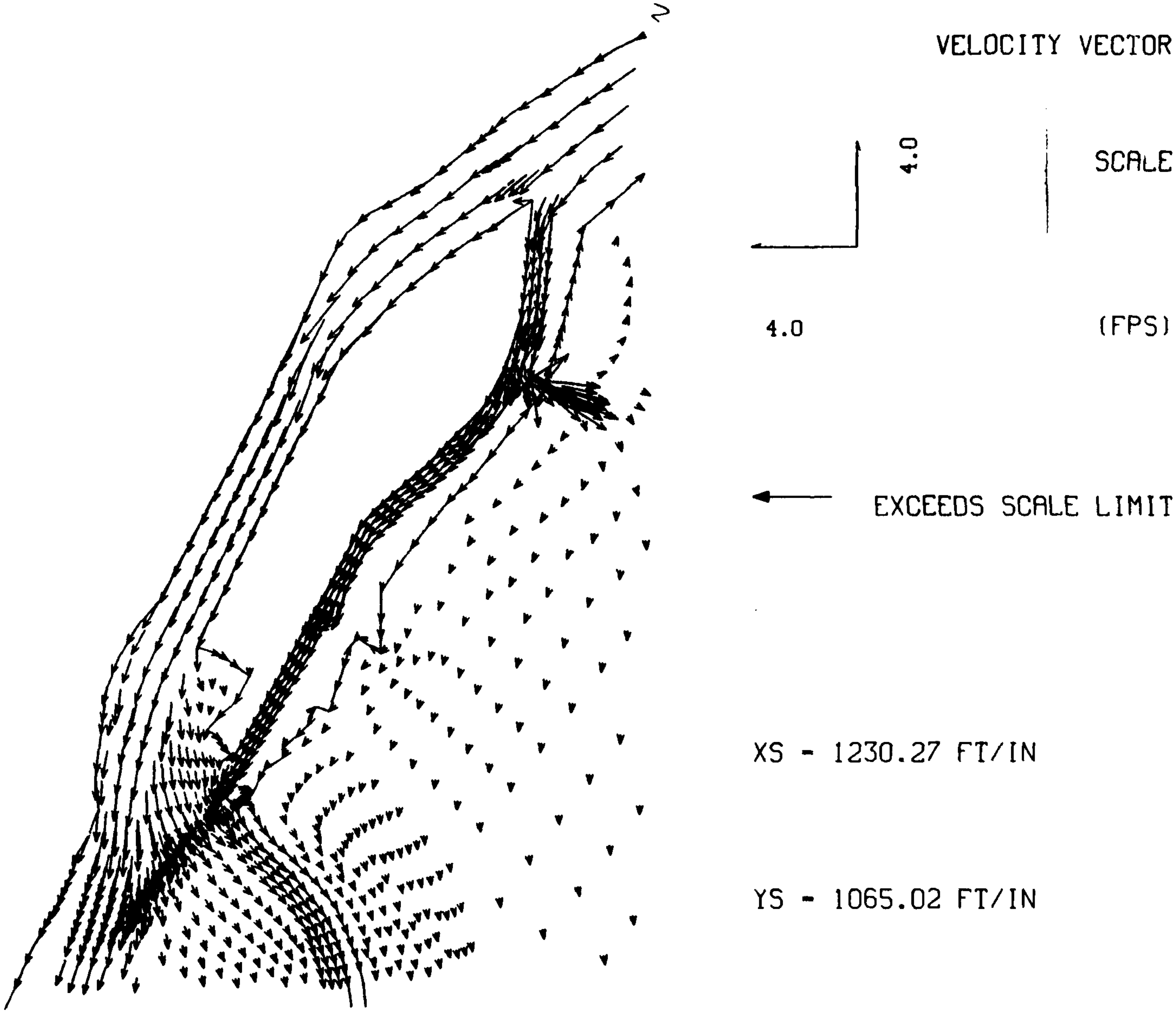


FIGURE E-16. Plan 2 Condition Current Patterns for Chillicothe Island and East River.

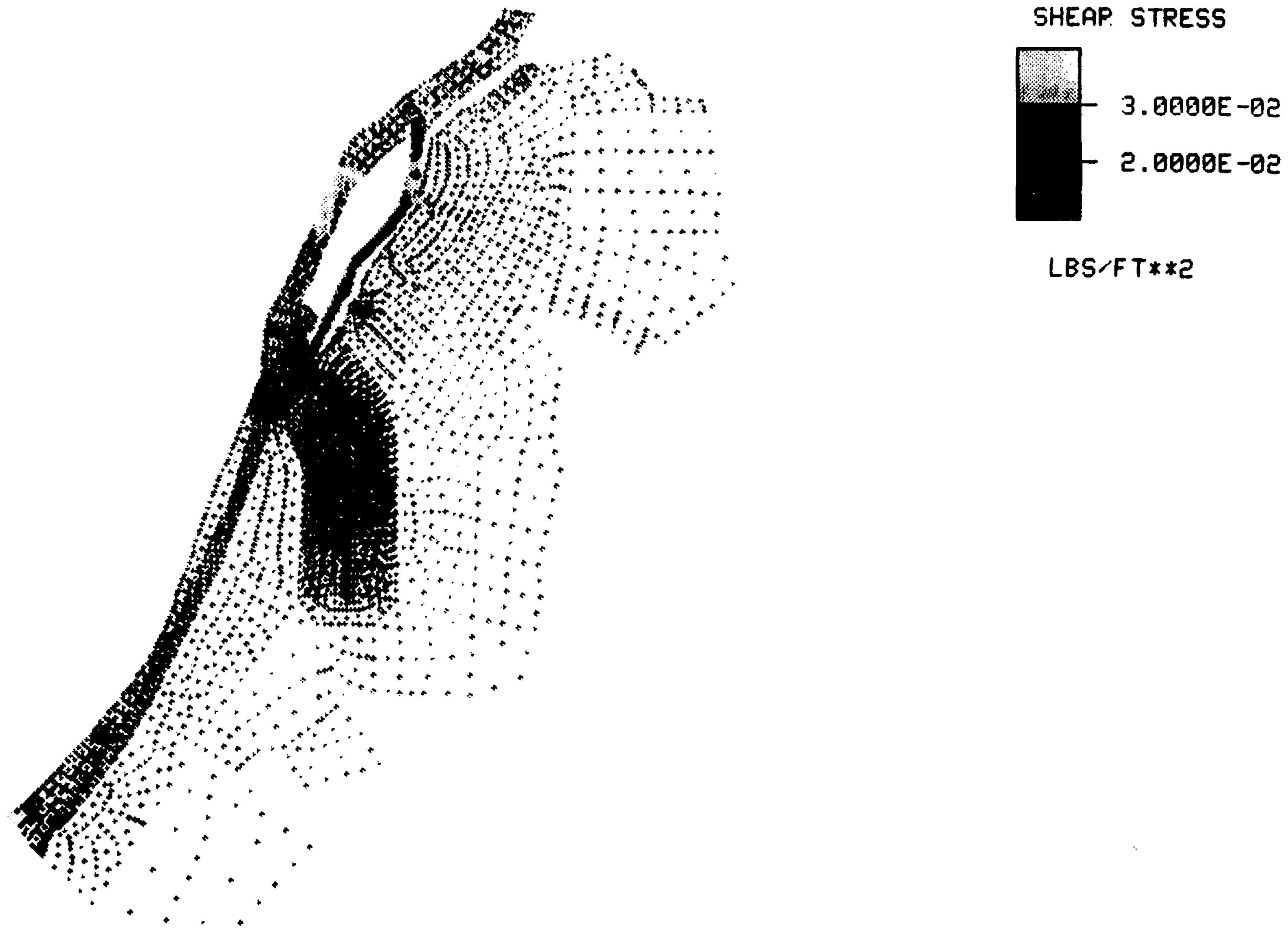


FIGURE E-17. Computed Bed Shear Stresses of Plan 2 Conditions.

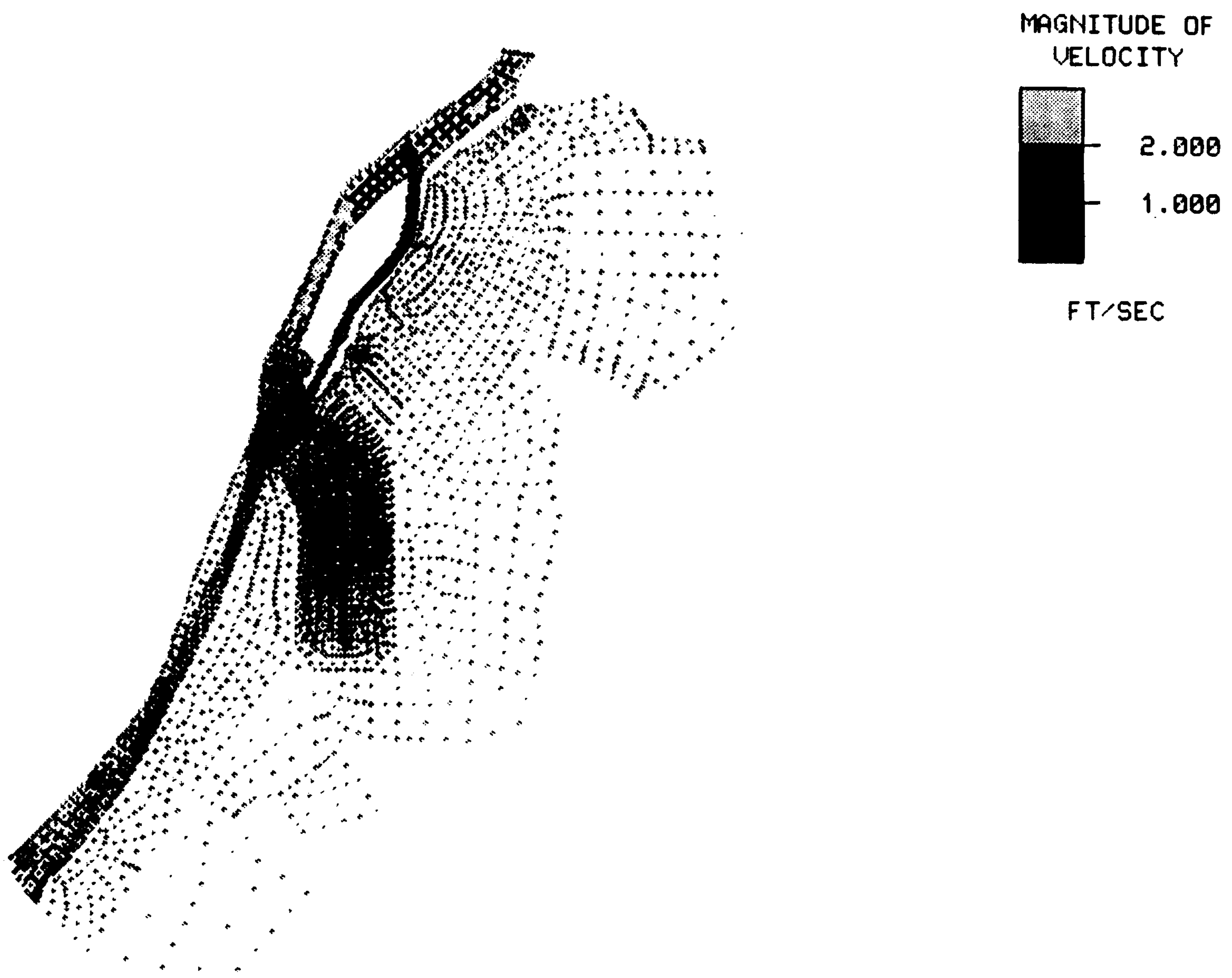


FIGURE E-18. Computed Velocities of Plan 3 Conditions.

The bed shear stresses in the upper cut range from 0.02 to 0.09 psf, indicating that the silts and sands will stay in suspension. In the reach between the upper and lower cuts, the bed shear stresses range from 0.007 to 0.025 psf, indicating higher bed shear stresses further downstream on the East River with the upper cut constricted. From the lower cut down through the East River outlet channel, there are no bed shear stresses above 0.02 psf.

E-7. CONCLUSIONS.

The proposed plans have three main hydraulic components: (1) the proposed barrier island and adjacent borrow area; (2) the East River silt plug removal and lower cut fill; and (3) the East River outlet channel. The use of the term "silt plug" does not imply that it is a silty material throughout the feature. In reference to Appendix G and boring PL-89-8 shown on figure G-5, only the top 4 to 5 feet is composed of silty material mixed with sand. The underlying material is composed of fatty clays.

A steady-state flow equal to the 2-year flood peak was selected for the analysis of the base and plan 1 conditions because of the limited availability of hydraulic and sediment data for model confirmation. This result is an analysis comparing the plan 1 conditions with the base, existing conditions and not a numerical model study. The significant hydraulic design questions regard head loss, navigation conditions, erosion of the barrier island and deposition in the locations of the present silt plug and the deep borrow area along the barrier island.

A steady-state flow of 35 percent exceedence (14,000 cfs and a water surface elevation of 441.5 feet) was selected for the analysis of plans 2 and 3 in order to produce in-bank hydraulic conditions in the East River. There are three hydraulic design questions concerning these two plans: (1) the effects of realignment on the East River outlet channel; (2) the effect on the East River, especially the silt plug excavation channel and the outlet channel, of constricting the upper cut; and (3) the effect of the wave height on the proposed barrier island at a 441.5-foot Peoria Lake pool.

The following are observations concerning the base and plan 1 tests:

a. The barrier island did not raise water surface elevations. It functioned as a submerged weir for which all hydraulic control was eliminated because of the high water surface elevation (figure E-21). Since the water surface elevation of the 2-year flood event is high enough to dissipate the effects of the proposed island, the even higher water surface elevation resulting from the 100-year flood would produce the same effects.

b. The most critical hydraulic condition is initial overtopping. However, the base test shows that a strong current pattern moves to the east as flow expands downstream from Illinois River mile 182. The existing islands are stable under such a condition and the barrier island is also

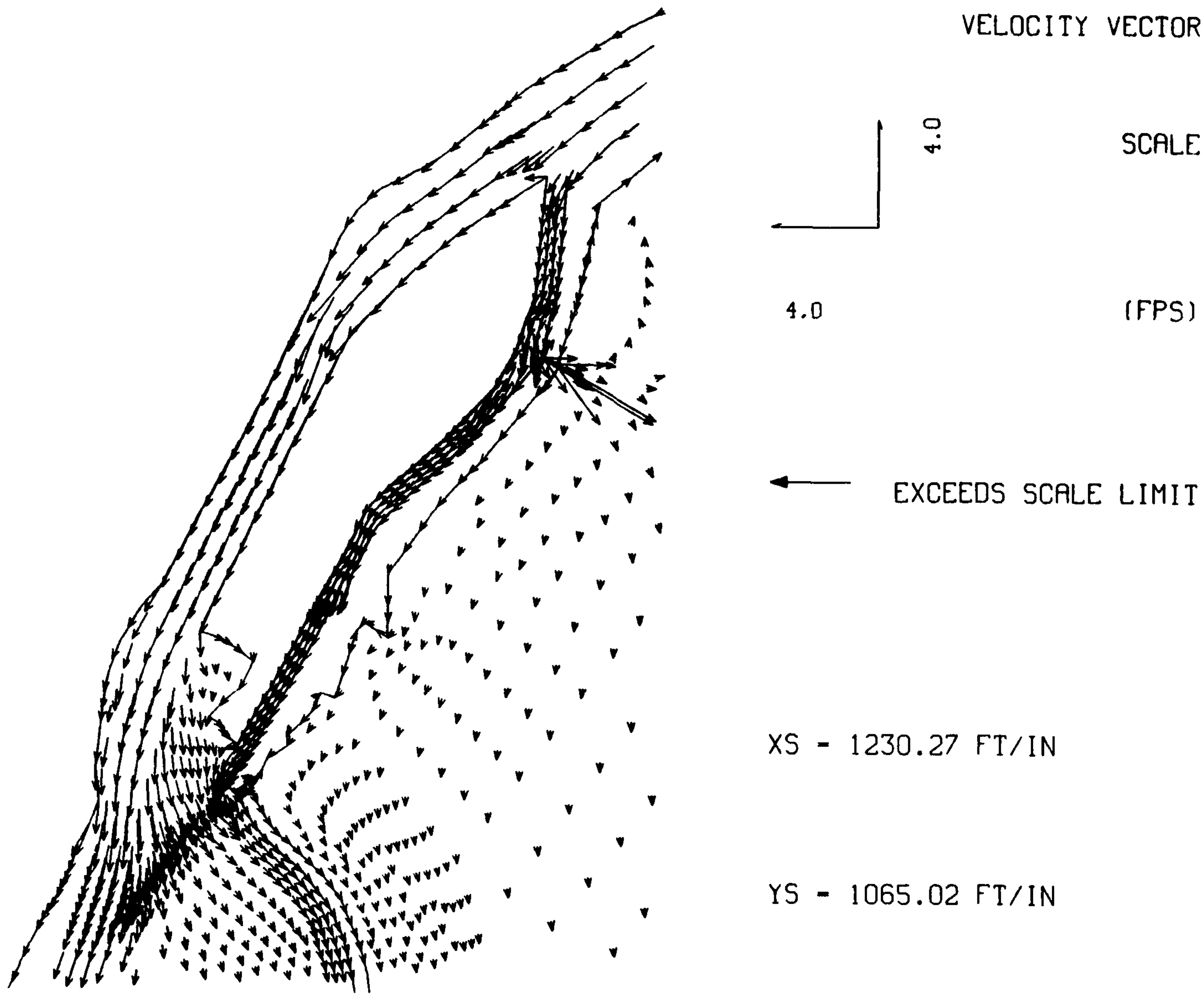


FIGURE E-19. Plan 3 Condition Current Patterns for Chillicothe Island and East River.

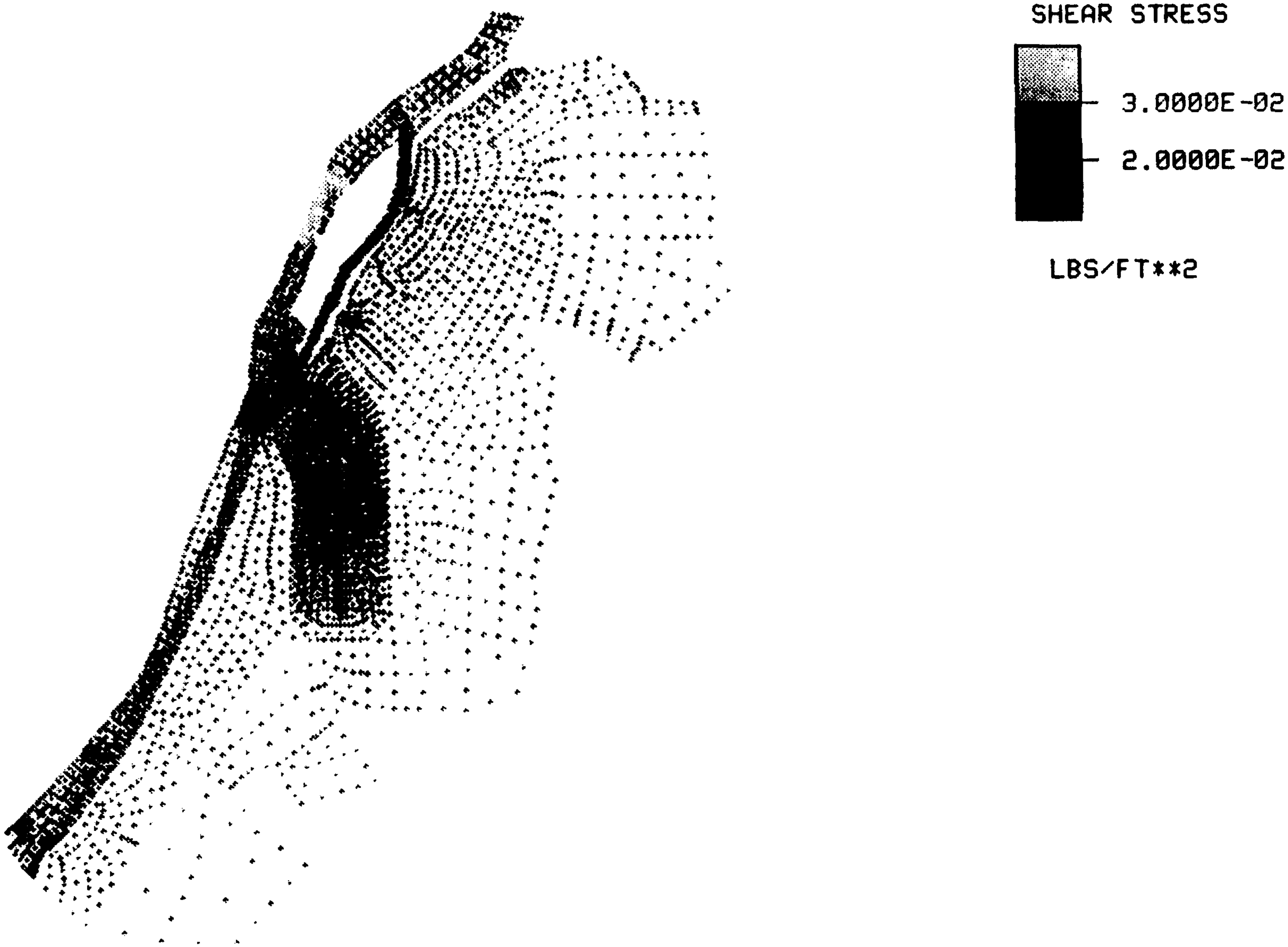


FIGURE E-20. Computed Bed Shear Stresses of Plan 3.

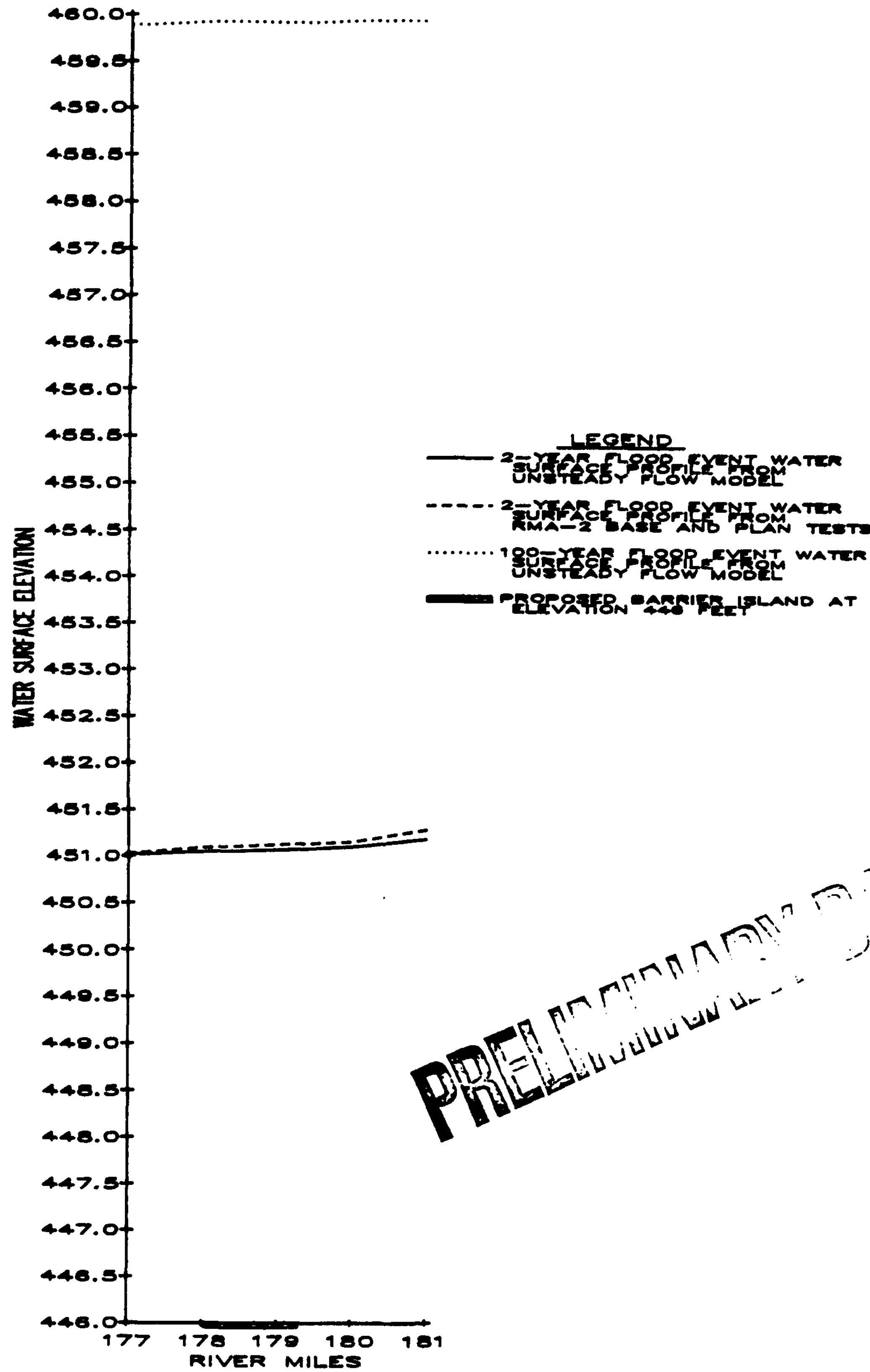


FIGURE E-21. Water Surface Profile of Peoria Lake.

expected to be because it will be constructed with cohesive sediments instead of sands.

c. The presence of the island and removal of the silt plug had no discernable impact on the current patterns or magnitudes in the navigation channel at this discharge. An increase in flow was anticipated down East River because the silt plug was removed, but this was not supported by model results. The slight velocity increase calculated in the silt plug area is likely due to the lowered roughness coefficients used to model tree removal. The high water surface elevation protects against strong navigation currents. As long as these conditions persist, lower flows will behave as calculated for this flood discharge. Current patterns shown in figure E-10 indicate no significant change in sediment patterns adjacent to privately owned land.

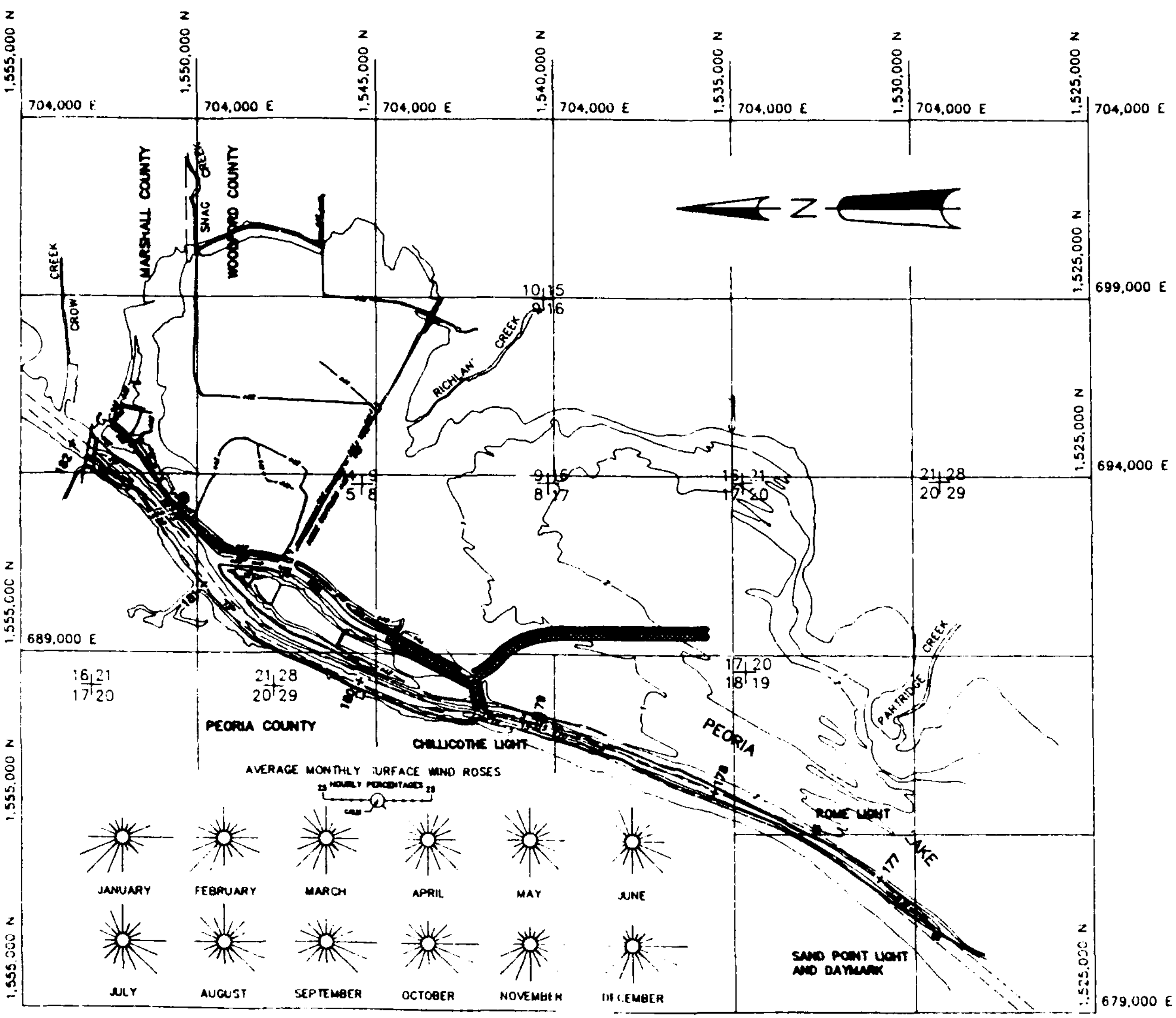
d. The wind and boat waves are expected to be less severe along the barrier island than along Chillicothe Island because of the shallow water limiting wave heights. Construction materials for the proposed barrier island are expected to be similar to Chillicothe Island constituents. The implication is that any protection against erosion used on the proposed island need not be greater than any that may have been used on Chillicothe Island.

The following are observations concerning plans 2 and 3:

a. The velocities for both plans 2 and 3 in the confluence and upstream of the upper cut are sufficient to transport sediment. The velocities in plan 2 are higher in this area indicating a higher flow capacity into the East River with the upper cut open. However, loss of energy through the open cut causes lower velocities for plan 2 in the channel between the upper and lower cuts. This reduces transport capacity and bed shear stresses in this reach which creates a tendency for coarse silt material to settle out. The opposite effect in caused by plan 3 which constricts the upper cut. The flow capacity into the upper East River is less, but there is less energy lost into the constricted cut. This results in higher velocities and bed shear stresses in the reach between the upper and lower cuts, indicating that the East River would retain a longer downstream reach if the upper cut were constricted.

b. The energy dissipation in both plans 2 and 3 downstream of the lower cut reduces both the velocities and bed shear stress in the silt plug excavation channel and the East River outlet channel. The bed shear stresses below the lower cut for these two plans are less than 0.02 psf, indicating that a tendency exists for the particle to settle out even with the upper cut partially closed.

c. The velocity vectors for both plans indicate that the dominant current pattern in the outlet channel is from the Illinois River navigation channel and not the East River. This flow configuration runs across the outlet channel creating fill conditions. Possible solutions are to extend Chillicothe Island downstream or to place dikes designed to redirect the flow downstream of Chillicothe Island.



LEGEND

- - - - - NAVIGATION CHANNEL FROM 1903 SURVEY.

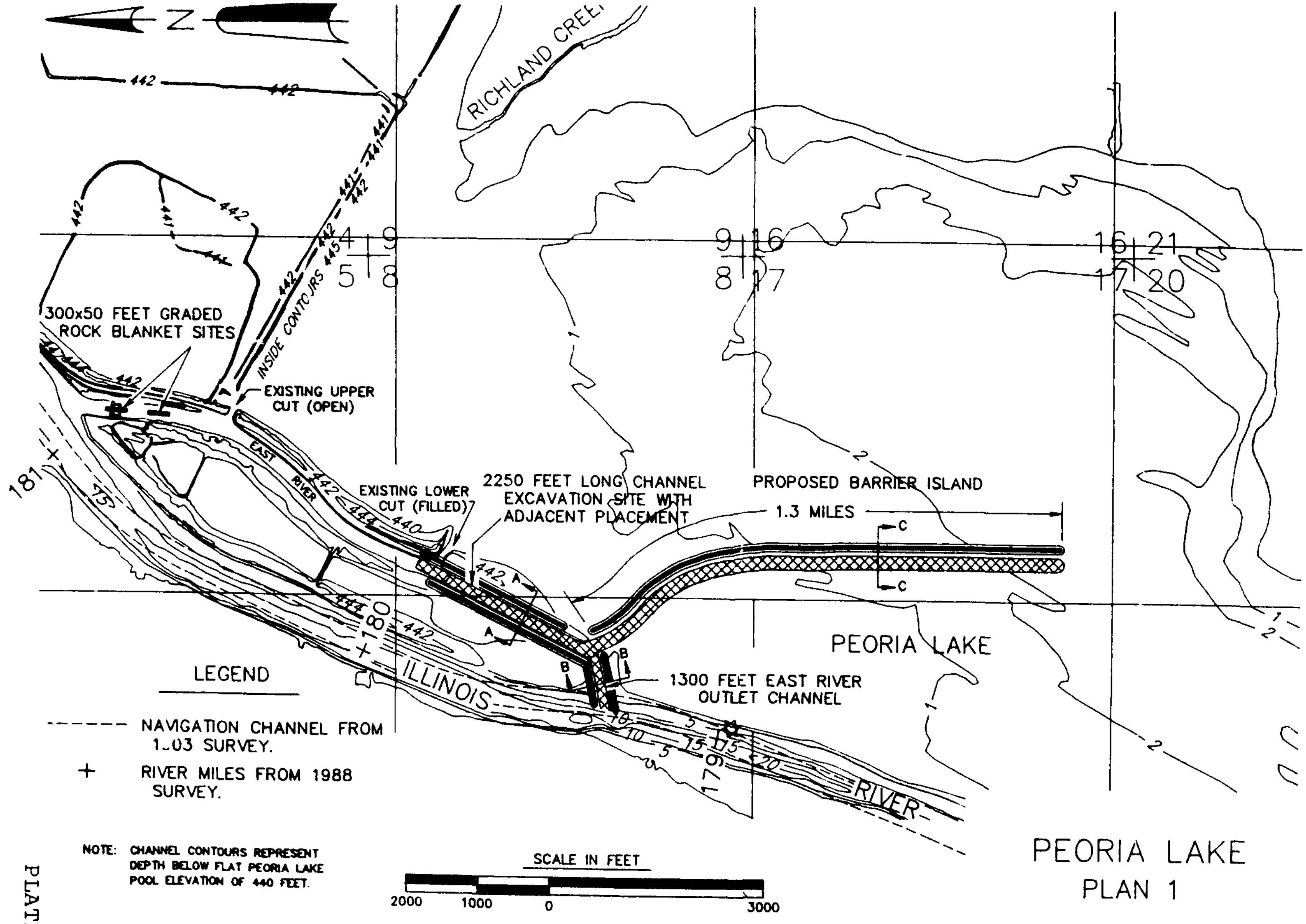
\+ RIVER MILES FROM 1988 SURVEY.

NOTE: CHANNEL CONTOURS REPRESENT DEPTH BELOW FLAT PEORIA LAKE POOL ELEVATION OF 440 FEET.

SCALE IN FEET

4000 2000 0 5000

PLATE E-1



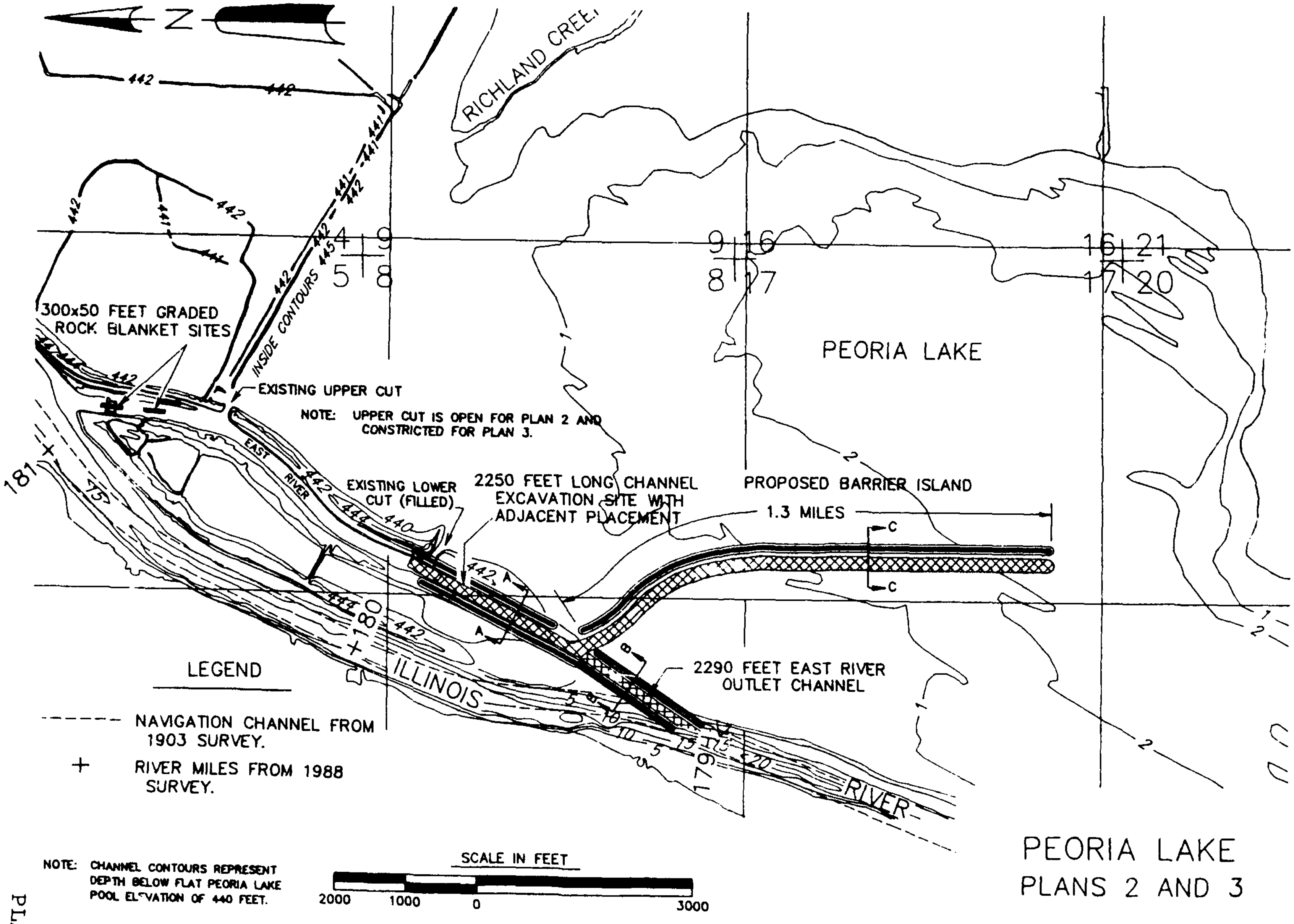
LEGEND

- - - - - NAVIGATION CHANNEL FROM 1.03 SURVEY.

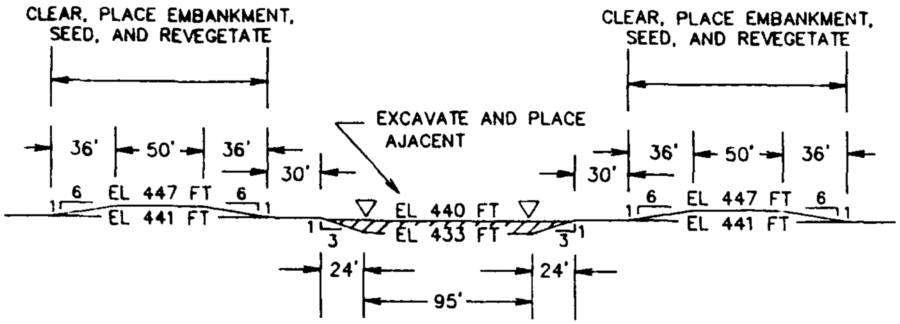
\+ RIVER MILES FROM 1988 SURVEY.

NOTE: CHANNEL CONTOURS REPRESENT DEPTH BELOW FLAT PEORIA LAKE POOL ELEVATION OF 440 FEET.

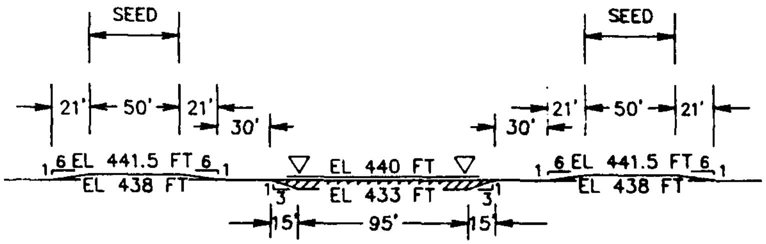
PEORIA LAKE
PLAN 1



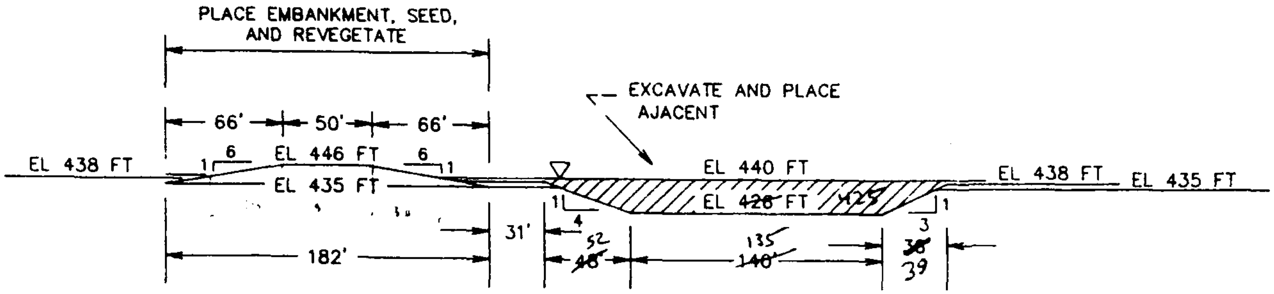
PEORIA LAKE
PLANS 2 AND 3



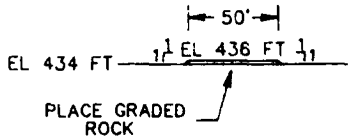
SECTION A-A
EAST RIVER EXCAVATION



SECTION B-B
EAST RIVER OUTLET CHANNEL

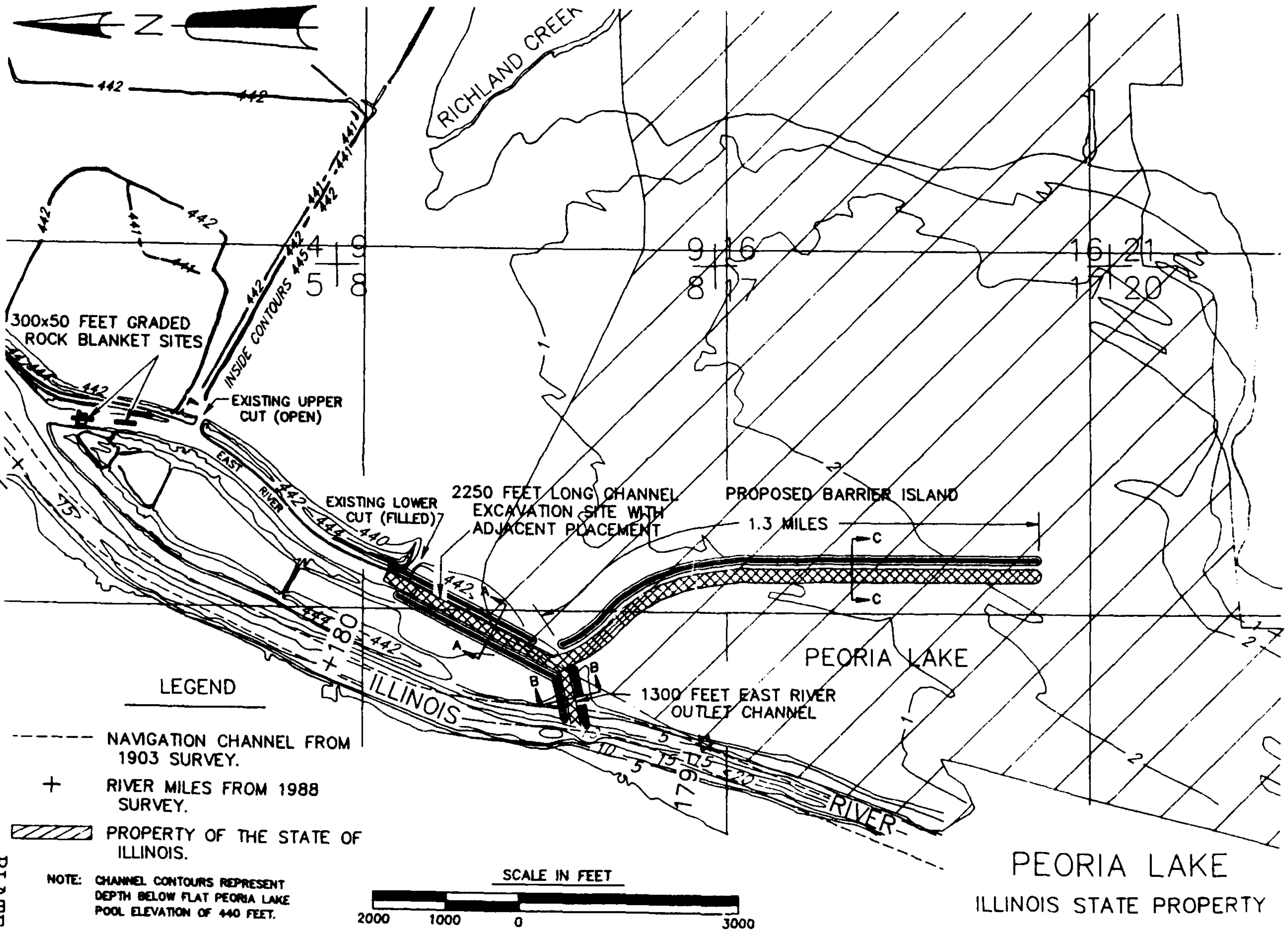


SECTION C-C
BARRIER ISLAND CONSTRUCTION



SECTION D-D
GRADED ROCK BLANKET

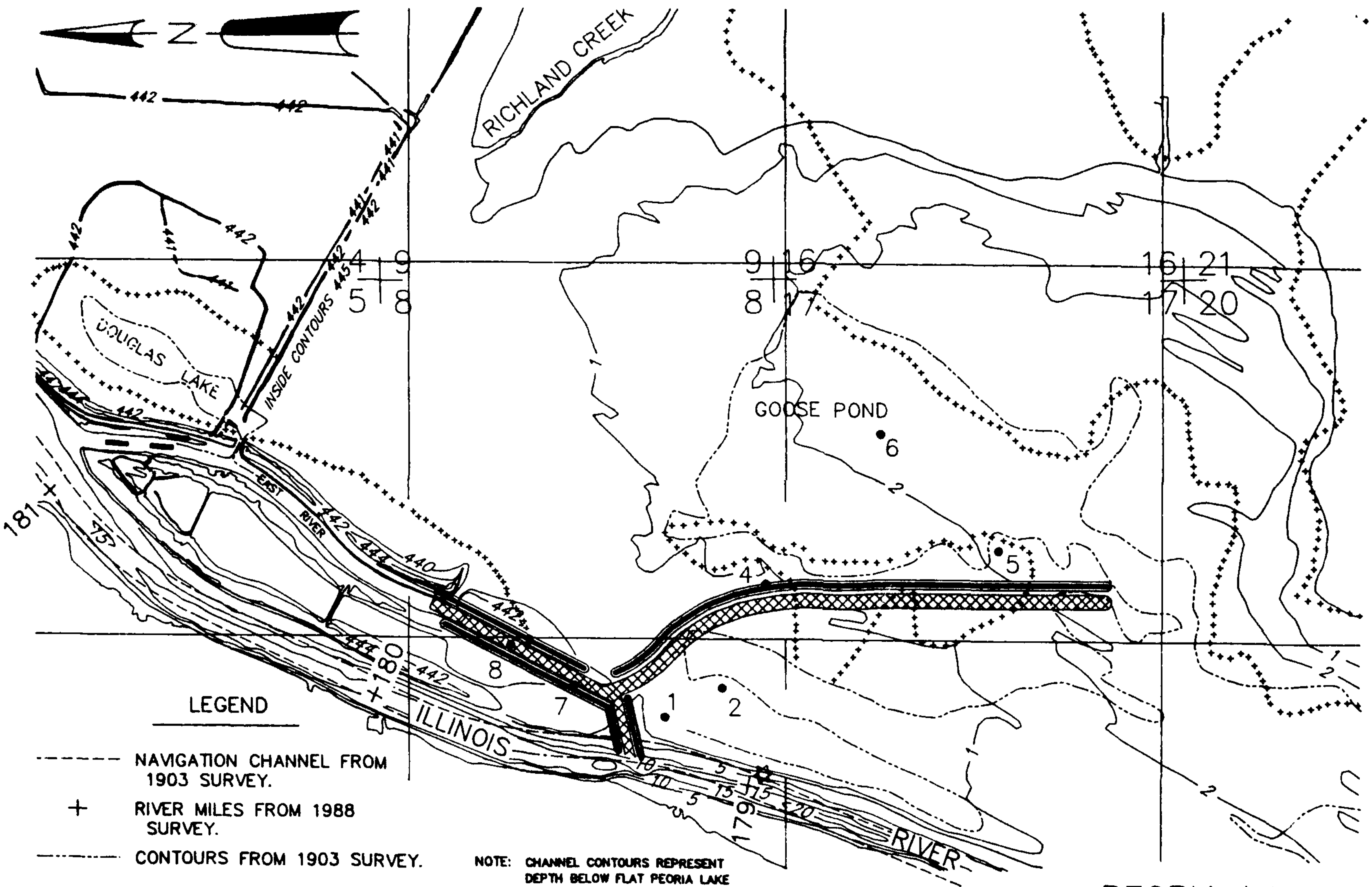
E-PLATE 4



PEORIA LAKE

ILLINOIS STATE PROPERTY

PLATE E-5



LEGEND

- NAVIGATION CHANNEL FROM 1903 SURVEY.
- + RIVER MILES FROM 1988 SURVEY.
- CONTOURS FROM 1903 SURVEY.
- TIMBER AND BRUSH LINE FROM 1903 SURVEY.
- • 1989 BORING LOCATIONS.

NOTE: CHANNEL CONTOURS REPRESENT DEPTH BELOW FLAT PEORIA LAKE POOL ELEVATION OF 440 FEET.

SCALE IN FEET

2000 1000 0 3000

PEORIA LAKE

1988 SOIL BORINGS AND
1903 TOPOGRAPHIC DETAILS

PLATE E-6

HYDROLOGY AND HYDRAULICS
FOR
FORESTED WETLAND MANAGEMENT AREA (FWMA)

APPENDIX F

UPPER MISSISSIPPI RIVER
ENVIRONMENTAL MANAGEMENT PROGRAM
DEFINITE PROJECT REPORT
WITH INTEGRATED ENVIRONMENTAL ASSESSMENT (R-6F)

PEORIA LAKE ENHANCEMENT
PEORIA POOL, ILLINOIS WATERWAY RIVER MILES 178.5 TO 181
STATE OF ILLINOIS

APPENDIX F
GEOTECHNICAL CONSIDERATIONS
FOR
FORESTED WETLAND MANAGEMENT AREA (FWMA)

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PEORIA LAKE ENHANCEMENT
PEORIA POOL, ILLINOIS WATERWAY RIVER MILES 178.5 TO 181
STATE OF ILLINOIS

APPENDIX F
GEOTECHNICAL CONSIDERATIONS FOR FORESTED WETLAND MANAGEMENT AREA (FWMA)

F-1. GENERAL.

The Peoria Lake Enhancement project, shown on plate 1 of the main report, is located within the Woodford County Conservation Area between River Miles (RM) 178.5 and 181.0 on the Illinois River. This area, located about 1 mile south of Chillicothe, Illinois, is currently managed as a wetland backwater refuge by the Illinois Department of Conservation (IDOC).

The purpose of this appendix is to present the development and evaluation a water control system for a proposed Forested Wetland Management Area (FWMA). This system will provide three interconnected cells with controlled water levels and reduce sedimentation into the refuge area. The elevation versus area and capacity curves for each unit and a total project curve are shown on plates F-1 thru F-4.

F-2. CLIMATE.

The climate in central Illinois is characterized by extreme temperatures and moderate precipitation. The National Weather Service operates a weather station in Peoria, Illinois, located at approximately RM 164, which has over 39 years of record. Temperatures range from a maximum of 113 degrees Fahrenheit in the summer to a minimum of -26 degrees Fahrenheit in the winter.

Most of the precipitation occurs in the summer and fall months, with April, May, June, and July normally the wettest months, having a monthly average of over 3.75 inches. Winters are normally the driest parts of the year. The average annual precipitation is 35.5 inches, and the average annual snowfall is 21.1 inches. Table F-1, shown below, lists the appropriate monthly precipitation at the Peoria gage for the 39 years of record during the periods 1948 to 1986.

TABLE F-1

Normal and Extremes of Monthly Precipitation

Month	Total Precipitation Normal Inches	Record Inches	Max. Yr.	Record Inches	Min. Yr.	Snowfall Normal Inches	Record Inches	Max. Yr.
January	1.57	6.54	65	.12	81	6.10	27.0	79
February	1.49	3.34	51	.26	69	4.45	14.0	50
March	2.77	6.90	85	.25	58	3.21	12.1	65
April	3.81	7.67	81	.65	86	0.77	6.00	70
May	3.78	8.93	70	.81	64	0.00		
June	4.51	9.39	74	.40	65	0.00		
July	4.14	7.65	51	.91	55	0.00		
August	3.06	9.70	81	.49	74	0.00		
September	3.70	11.24	61	.00	79	0.00		
October	2.60	7.40	86	.01	64	0.05	2.00	67
November	2.45	10.22	85	.43	53	1.21	6.20	51
December	2.07	5.77	82	.24	58	5.25	15.5	51

F-3. HYDROLOGY.

Illinois River discharge frequency relationships and corresponding water surface profiles were developed by the Rock Island District, Corps of Engineers, in a 1987 study entitled Illinois River Water Surface Profiles, River Miles 70 to 230, Unsteady Flow Model. Plate F-5 presents pertinent data from this study. Actual water elevations are recorded daily at Chillicothe, Illinois (RM 178.0). The Chillicothe gage was discontinued in 1973.

Plates 4 and 6 of the main report show daily stage hydrographs for the period of record 1960 through 1973. These data were used to compute monthly and year-round elevation duration relationships for the project site as presented on plates F-6 through F-9. The 50-percent duration elevation can be interpreted as the average elevation. The months of August, September, October, and December have the lowest normal elevations, referenced to feet above MSL, of 440.5, 440.5, 440.6, and 440.6, respectively. The year-round normal elevation is about 440.8 feet. Typical floods appear to last for at least 25 days and raise the water surface about 5 feet. Actual water elevations also are recorded at the Peoria Boat Yard (RM 164). The period of record is 1960 through 1989. The year-round normal elevation is 440.6 feet.

F-4. LEVEE AND WATER CONTROL STRUCTURES.

The proposed project includes a levee system constructed to provide three interconnected cells with the controlled water surface elevations. The system will be a stepped up configuration with the lower cell levee elevation being 446 and the middle and upper cells having levee elevations of at least 448, and 450, respectively. The levee heights were selected to provide 2 feet of water and 2 feet for freeboard. Plates 13 through 19 of the main report show the levee layout and details.

Significant aspects of the project are the stop log water control structure between the Illinois River and the lower refuge and the structures between each of the refuge areas, as shown on plates 13 of the main report. Each of these control structures will have a weir length of 20 feet. The purpose of these structures is to control water levels into each cell independently and to allow floodwaters to enter the interior of the levee system during normal operation of the structures. The structures were sized to have a capacity to convey enough water to fill the interior of the levees to within 1 foot of the top of the respective levee before overtopping occurs during a flood event greater than the respective levee height. This will equalize the hydrostatic pressure and reduce damage during flood events.

By routing a typical Illinois River flood event, assuming a rate of rise of 1 foot per day, it is estimated that the interior of the levee system would fill to within 1 foot of each levee top before overtopping with the proposed structures. The 1-foot-per-day rate of rise was an average value correlated to historic flood hydrographs. Once overtopping occurs, the interior will fill and the head difference will be the same as the typical rate of river rise. A typical Illinois River flood event will recede approximately 0.5 foot per day. The project areas will drain at about the same rate as the river.

The area of conveyance for the 100-year flood event was computed for existing conditions and compared to that of the proposed conditions. There was approximately a 2.5-percent reduction in the cross-sectional area at the project site. The reduction occurs in the over bank area which does not normally convey much of the flood flow. The estimated difference in flood elevations for all floods is substantially less than 0.1 foot. A channel cross section for existing and proposed conditions is shown on plate F-10. Table F-2 is a monthly tabulation which lists the number of times that a flood peaked above elevation 447 during the years 1960 through 1988 at the project site.

TABLE F-2

Peak Months That Elevation 447
Was Exceeded (1960-1988)

Month	Number	Month	Number
January	2	July	1
February	6	August	0
March	8	September	1
April	15	October	2
May	12	November	1
June	6	December	2

F-5. PUMP SIZE.

Another significant aspect of the project is the well station located in Cell A as shown on plate 13 of the main report. The station will be a one pump system with the capability to pump from the ground water into the most upland unit Cell A.

The pump was sized in order to fill the upper, middle, and lower cells to elevations 448, 446, 444, respectively, in approximately 10 days. This will be accomplished by at least a 4,500-gallons-per-minute (gpm) pump. The effects of evaporation, infiltration, and seepage were all considered in the pump sizing. It was assumed that under less than ideal conditions rainfall will not be a factor. Plate F-11 is a graph of alternative pump sizes and the corresponding pumping days. A 6,000-gpm pump was selected because it was a cost-effective and conservative pump that would satisfy the IDOC requirements. A typical Illinois River flood will recede approximately 0.5 foot per day. A pump was not required to evacuate storage because the cells will recede at the same rate as a Illinois River flood.

F-6. FLOODPLAIN REQUIREMENTS.

The Illinois Department of Transportation, Division of Water Resources (IDOT/DWR) regulates floodway construction activities to ensure that they do not result in increased flood heights and damages to other properties. The proposed project can be divided into two separate features which are located within the Illinois River floodway: (1) construction of the FWMA; and (2) construction of the barrier island and side channel excavation. Due to the nature and location of each of the project features, separate hydraulic analysis were carried out to determine the effect of the proposed project on flood heights.

The IDOT/DWR required a worst case analysis to determine the hydraulic effect of the FWMA. The worst case analysis was performed by modeling the Illinois River through Peoria Lake from RM 174 to 182 using the HEC-2 backwater program. It was determined that a flow corresponding to elevation 450, which is just prior to overtopping of the highest levee, would be the most critical for this analysis. The discharge associated with elevation 450 was obtained by extrapolating the elevations and discharges from the Woodford County Flood Insurance Study. The resulting discharge of 44,000 cubic feet per second (cfs) is approximately the 2-year discharge. It was determined that the FWMA would reduce the flow area of a typical cross section by 5 percent at elevation 450. In order to satisfy the IDOT/DWR's request of a worst case analysis, the entire study area was encroached by 5 percent on each side of the river. Table F-3 compares the resulting water surface elevations for the encroached or combined effects with the unencroached or base profiles. The changes are less than the allowable 0.1 foot. The 100-year flow also was evaluated for hydraulic impacts and the results were less significant than the lower elevations and associated discharges.

TABLE F-3

Illinois River Encroachments
Q = 44,000 cfs

	Water Surface Elevations		
Cross Section	Base (NGVD)	Combined Effect (NGVD)	Difference (feet)
173.25	450.14	450.14	.00
175.00	450.20	450.22	.02
176.00	450.23	450.26	.03
177.00	450.26	450.29	.03
177.90	450.30	450.34	.04
179.00	450.33	450.37	.04
180.90	450.35	450.40	.05
181.86	450.38	450.43	.04
183.00	450.42	450.48	.06

The proposed barrier island and side channel excavation were modeled by the Waterways Experiment Station (WES) using the TABS-2 unsteady model. Due to the unlikelihood that other riverine construction will be undertaken in the project vicinity, a singular effects evaluation will be considered as the worst case analysis. It was concluded that the proposed project would not increase flood heights at the 2-year or higher discharges. The IDOT/DWR expressed concern that the impact on water surface profiles was not addressed for the critical condition before overtopping of the barrier island. Due to time and funding constraints, the HEC-2 backwater program was used for this analysis. The flow deemed most critical for this analysis was the 50-percent duration flow of 14,000 cfs. The water surface elevation associated with this flow is 441.5 feet and was used as a starting water surface elevation for the HEC-2 model. A comparison of the water surface elevations from RM 174 to 182 for the existing conditions with proposed conditions resulted in a 0.00 foot difference.

CELL C (LOWER)
STORAGE/AREA VS ELEVATION CURVE

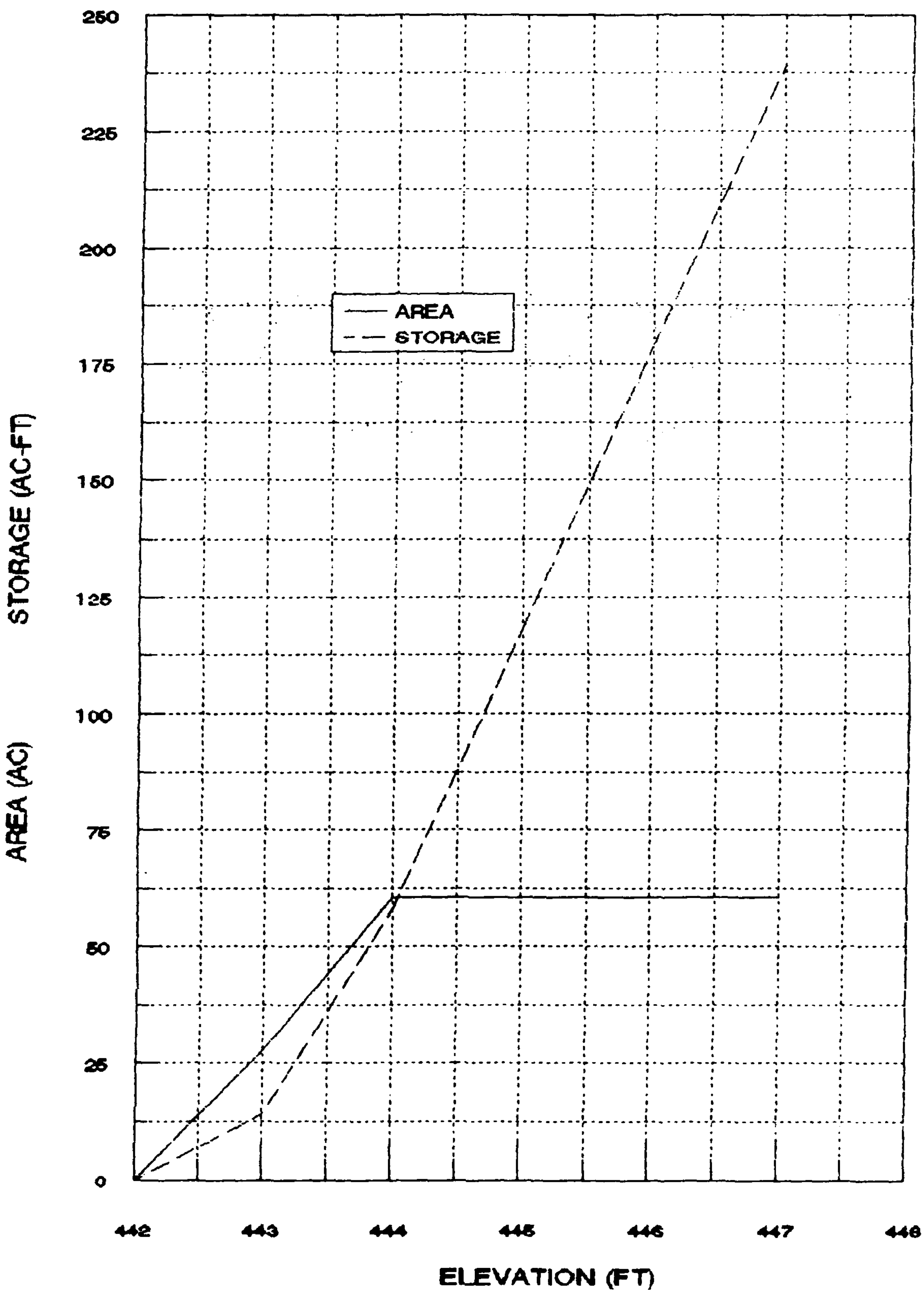
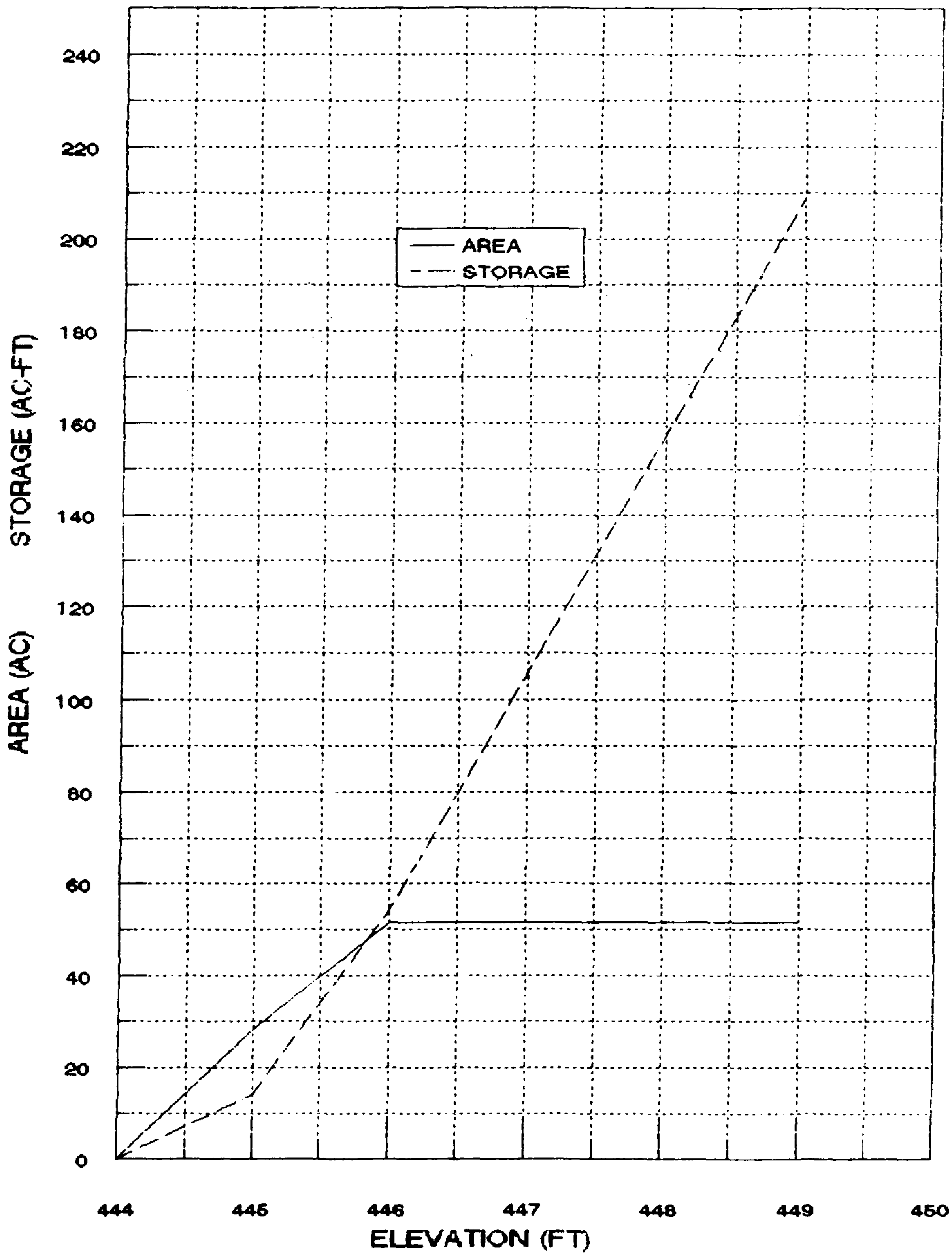


PLATE F-1

NOTE: NORMAL OPERATING ELEVATION=444

CELL B (MIDDLE)
STORAGE/AREA VS ELEVATION CURVE



NOTE: NORMAL OPERATING ELEVATION = 446

PLATE F-2

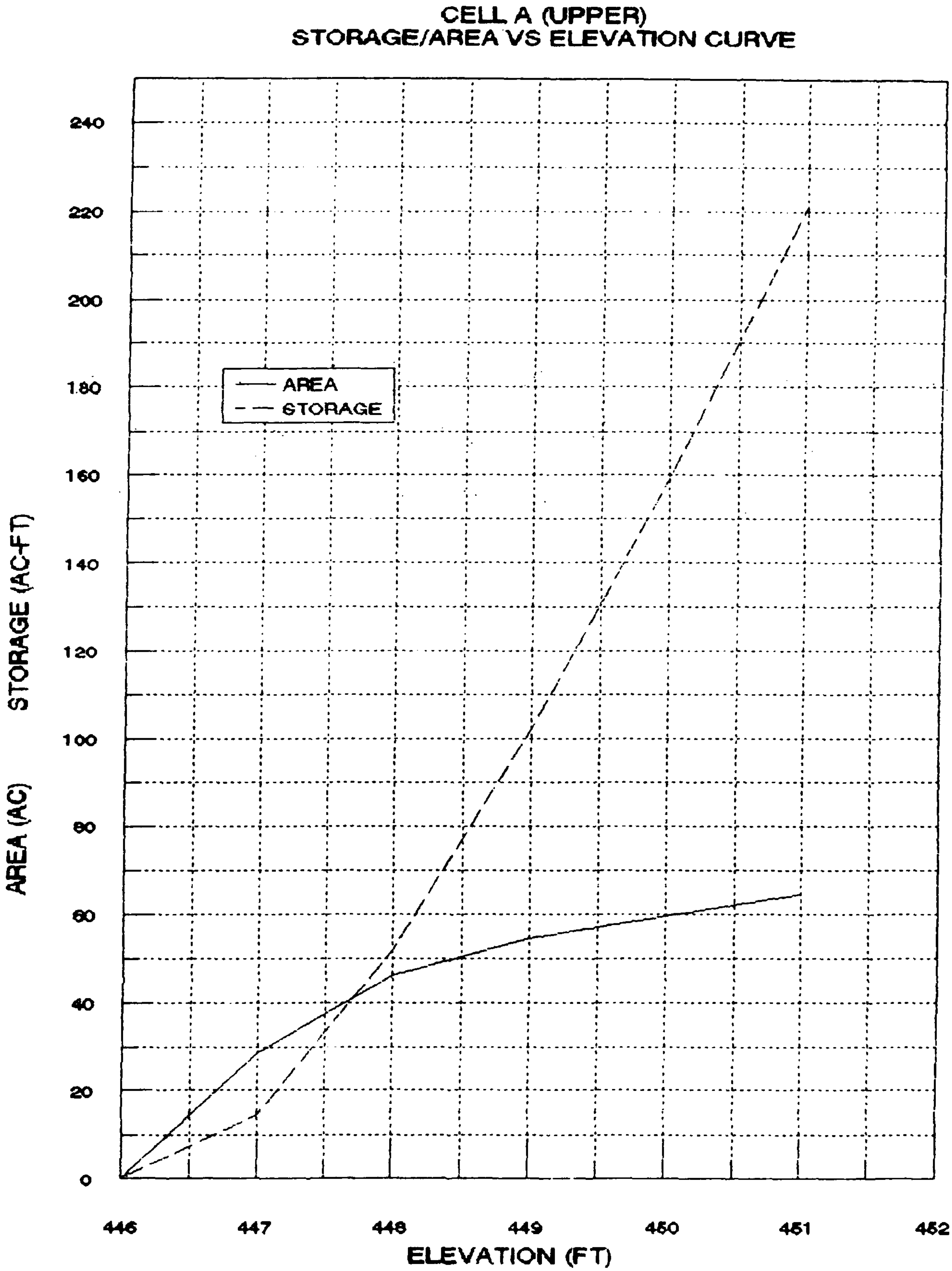
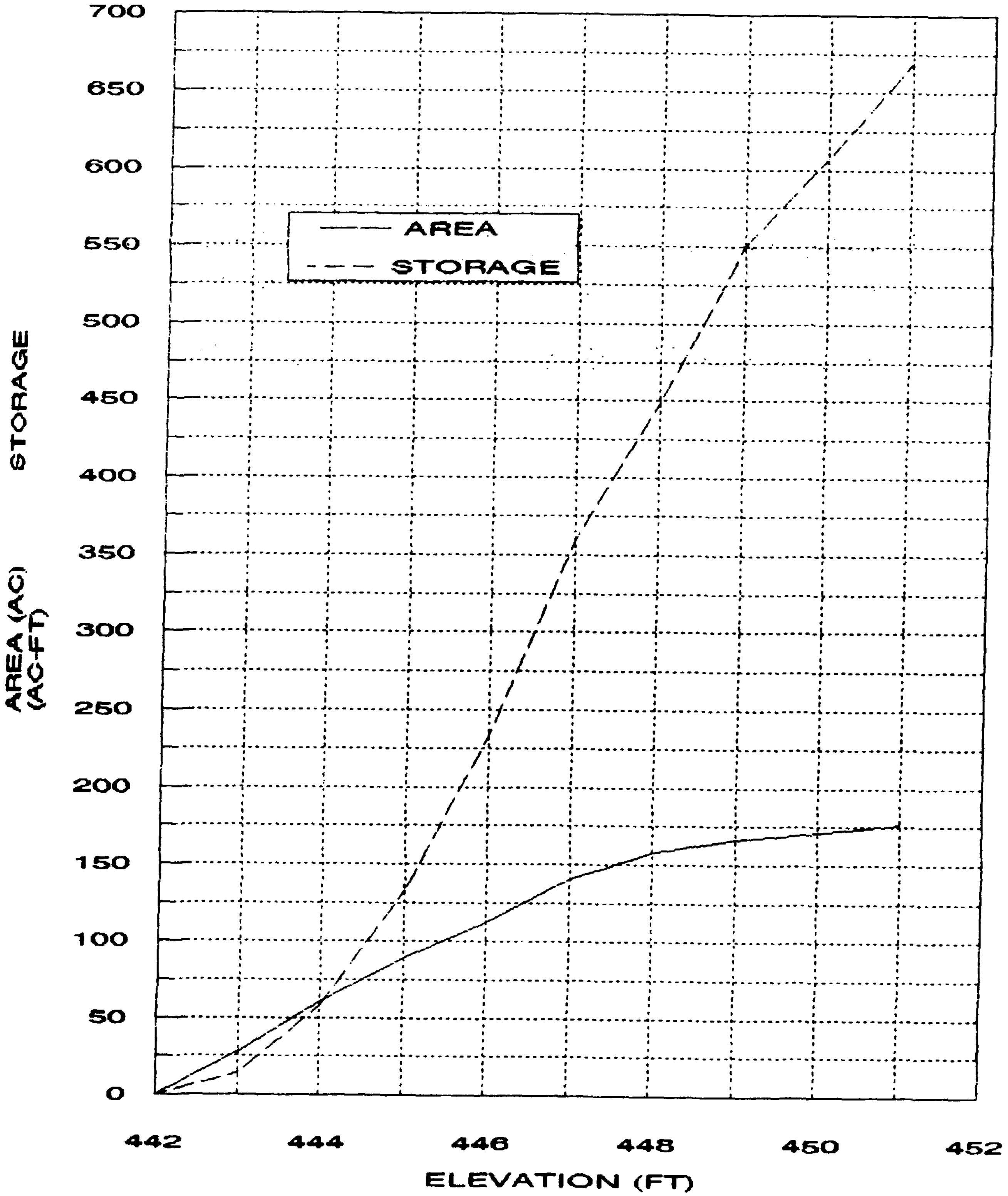
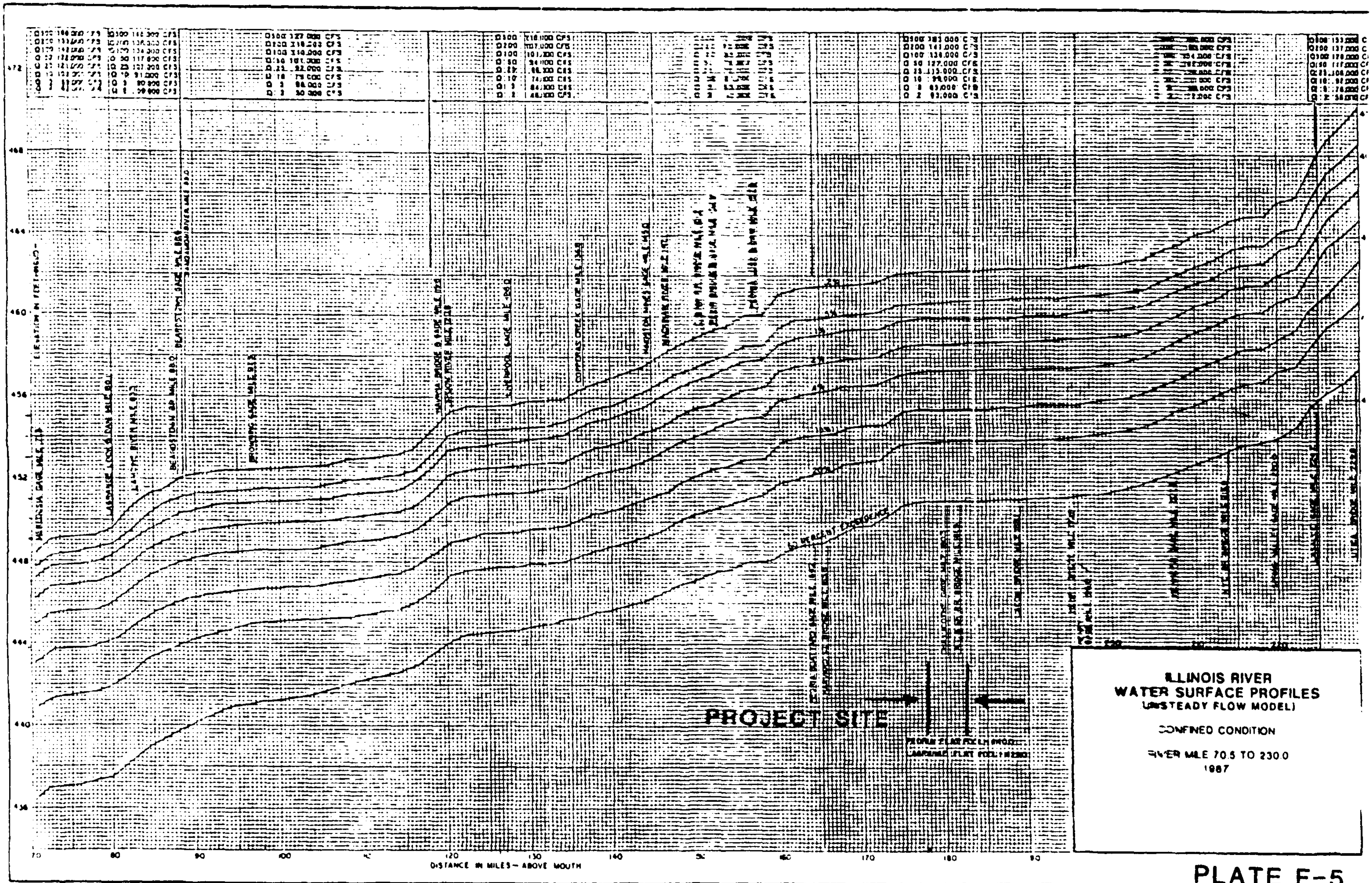


PLATE F-3

NOTE: NORMAL OPERATING ELEVATION= 448

ALL CELLS
STORAGE/AREA VS ELEVATION CURVE





ILLINOIS RIVER
WATER SURFACE PROFILES
(UNSTEADY FLOW MODEL)
CONFINED CONDITION
RIVER MILE 70.5 TO 230.0
1987
PROJECT SITE
DISTANCE IN MILES — ABOVE MOUTH
ELEVATION IN FEET (NGVD)

PLATE F-5

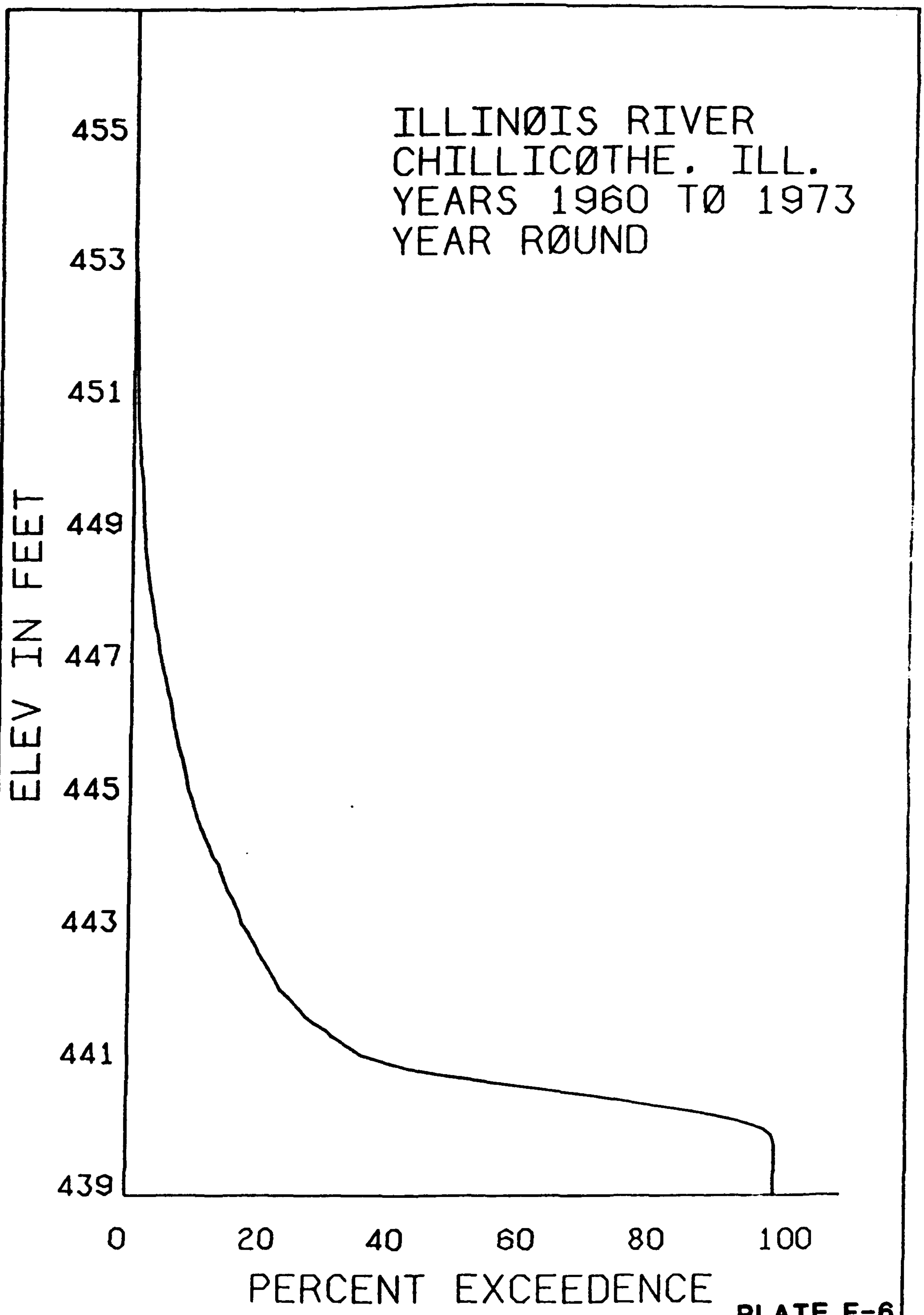
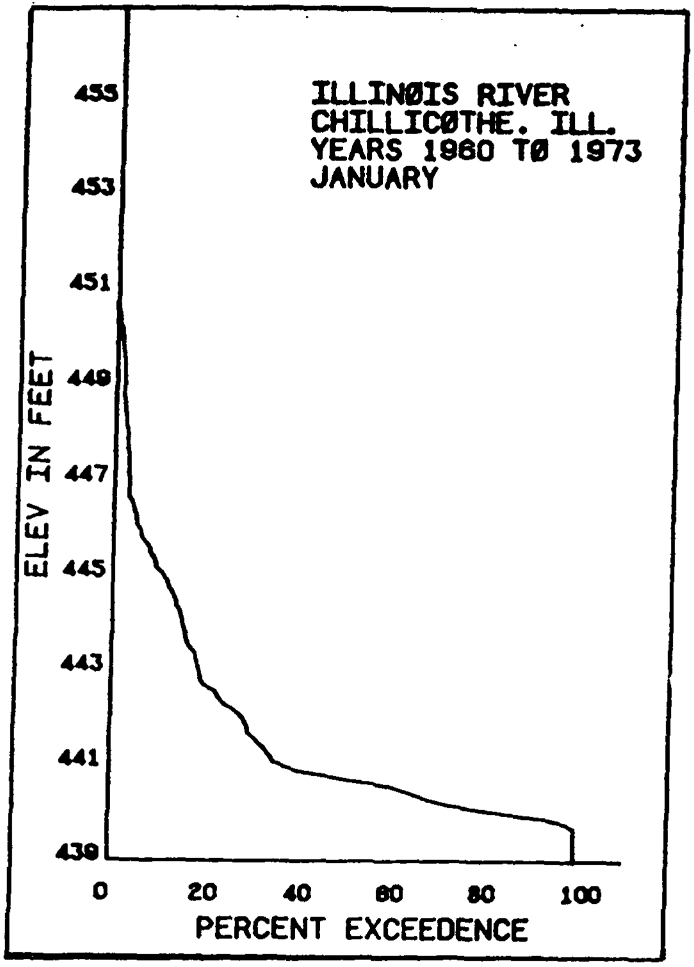
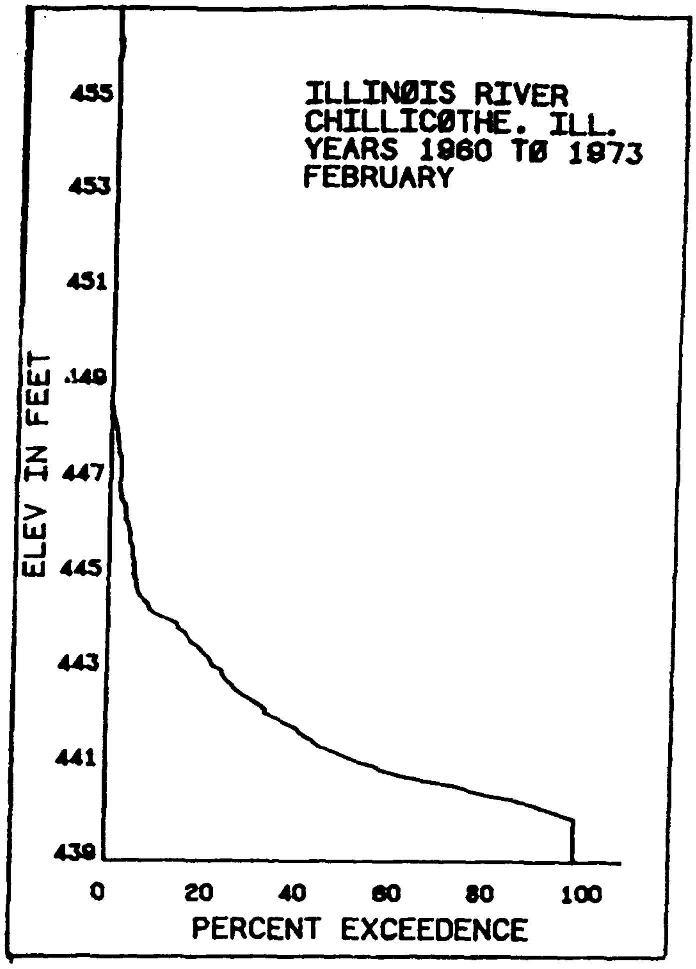
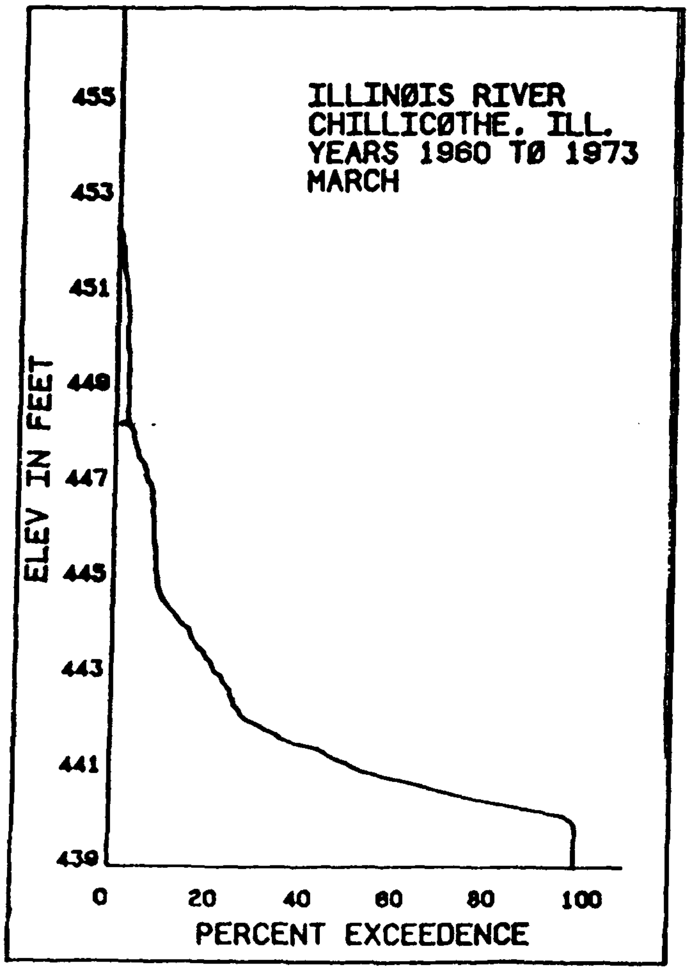
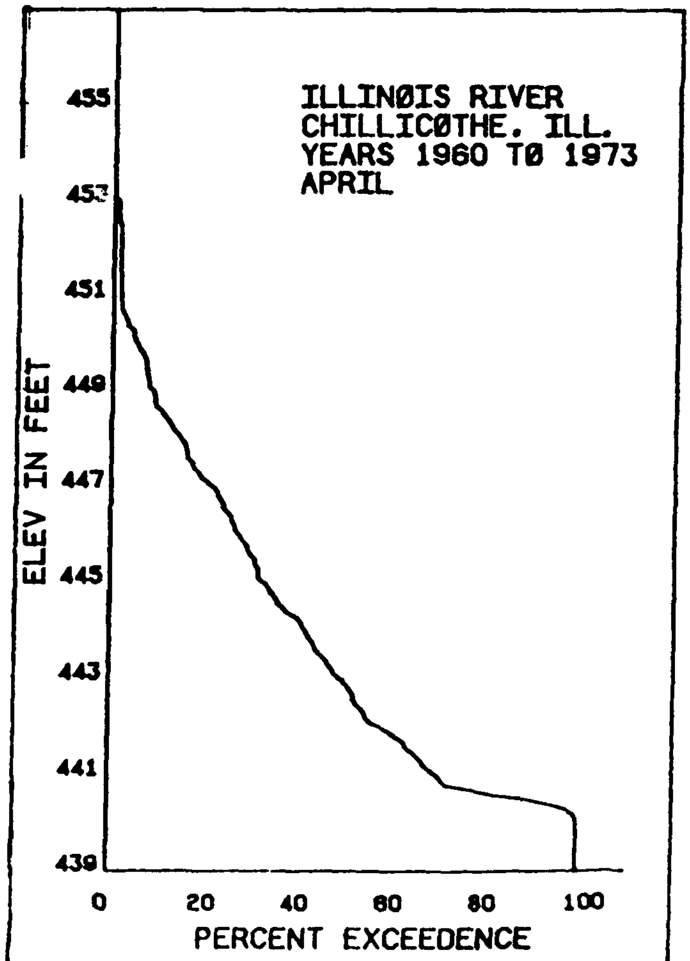

ILLINØIS RIVER
CHILLICØTHE. ILL.
YEARS 1960 TØ 1973
YEAR RØUND
ELEV IN FEET
455
453
451
449
447
445
443
441
439
0
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE F-6


ILLINØIS RIVER
CHILLICØTHE. ILL.
YEARS 1960 TØ 1973
JANUARY
ELEV IN FEET
455
453
451
449
447
445
443
441
439
0
20
40
60
80
100
PERCENT EXCEEDENCE


ILLINØIS RIVER
CHILLICØTHE. ILL.
YEARS 1960 TØ 1973
FEBRUARY
ELEV IN FEET
455
453
451
449
447
445
443
441
439
0
20
40
60
80
100
PERCENT EXCEEDENCE


ILLINØIS RIVER
CHILLICØTHE. ILL.
YEARS 1960 TØ 1973
MARCH
ELEV IN FEET
455
453
451
449
447
445
443
441
439
0
20
40
60
80
100
PERCENT EXCEEDENCE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YEARS 1960 TØ 1973
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ELEV IN FEET
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441
439
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20
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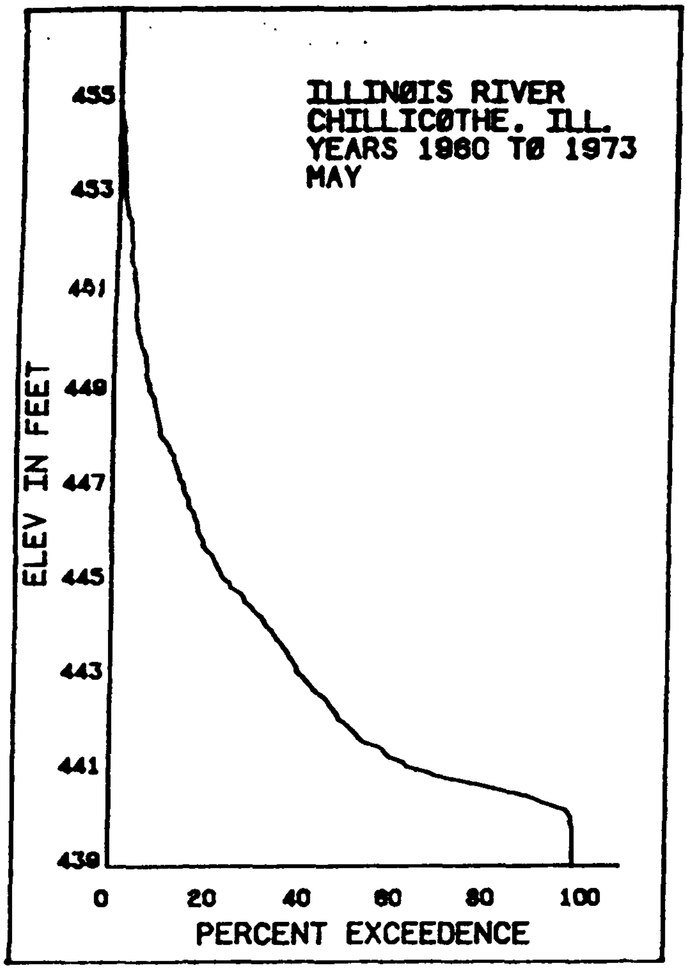
PERCENT EXCEEDENCE

PLATE F-7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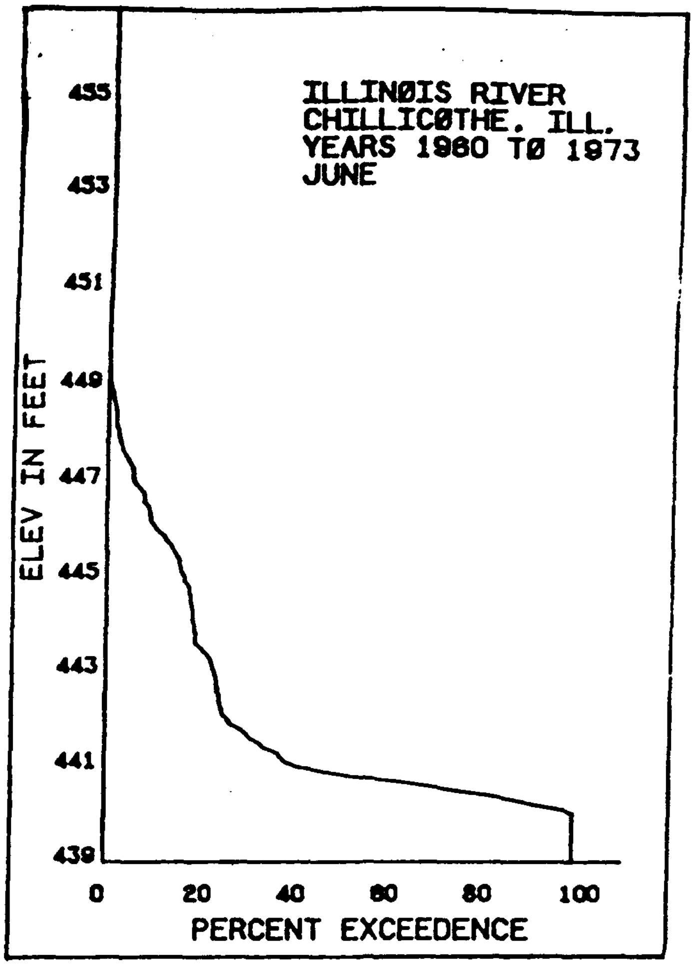
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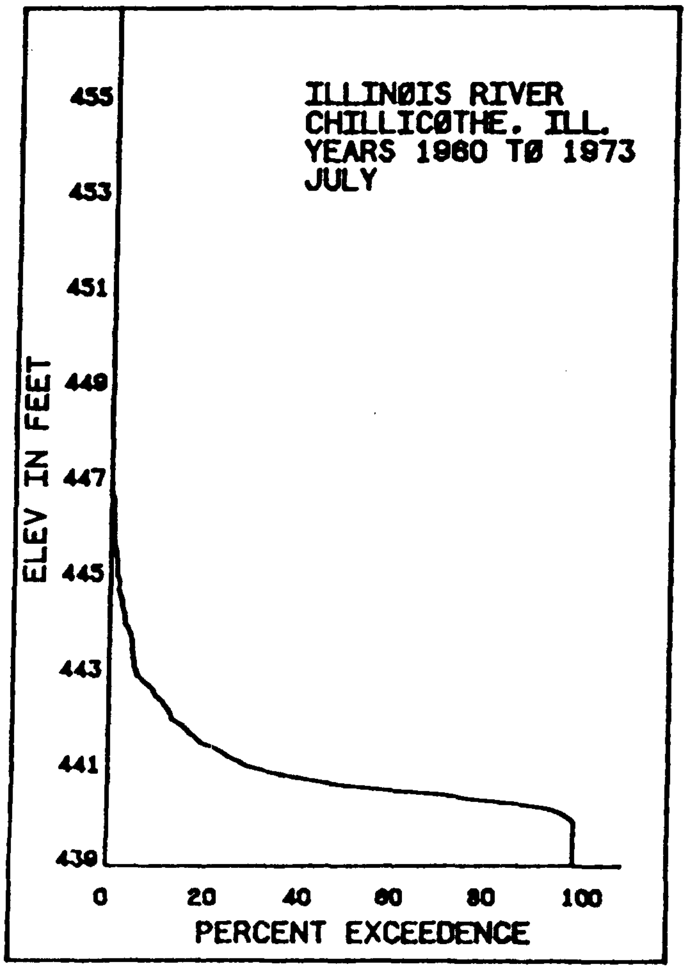
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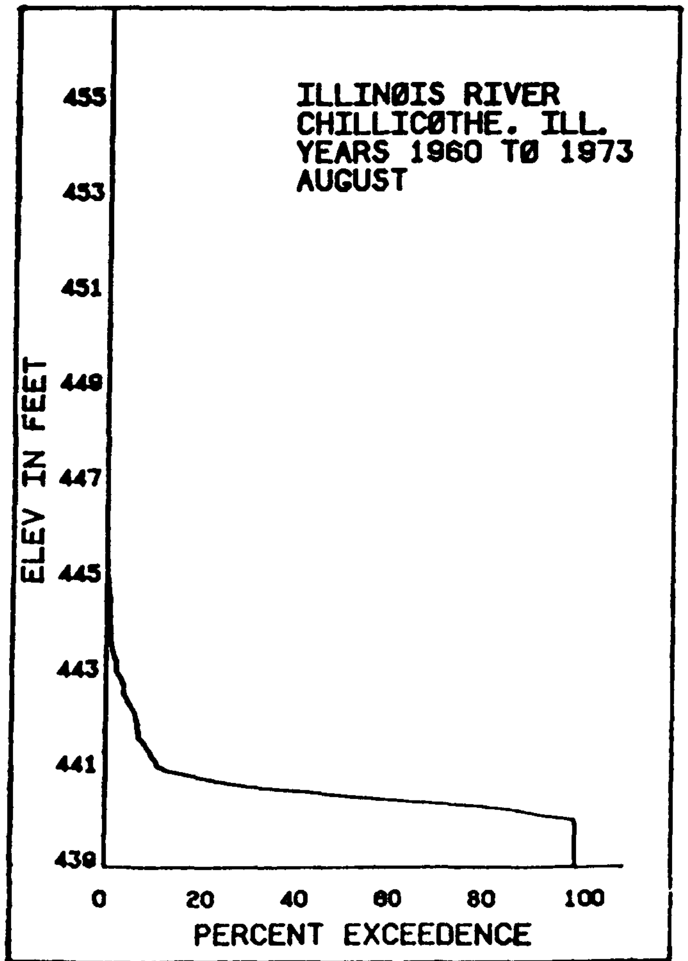
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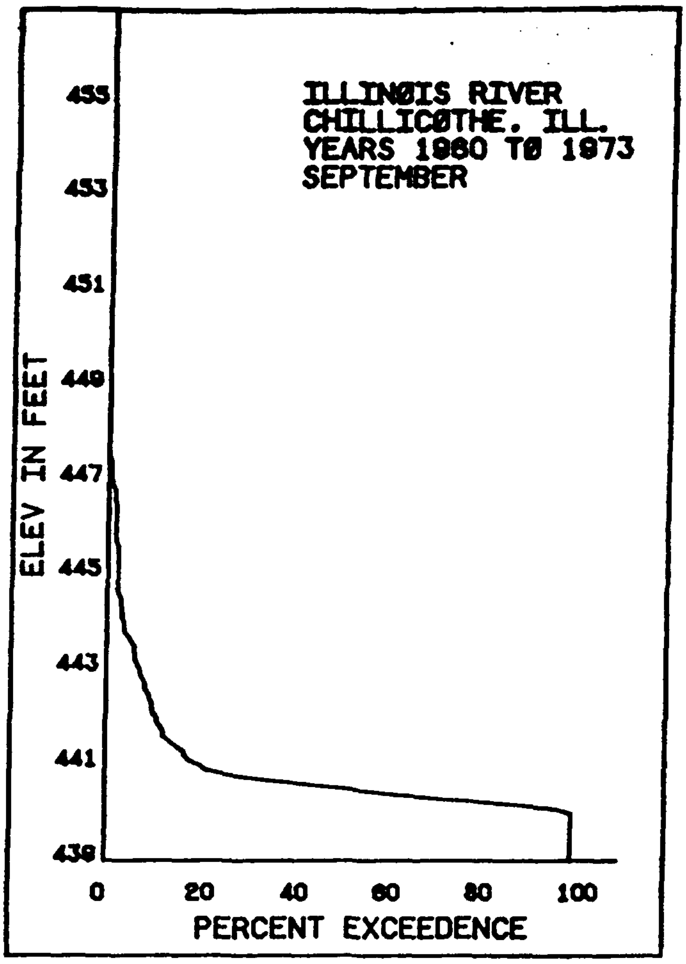
100
PERCENT EXCEEDENCE

PLATE F-8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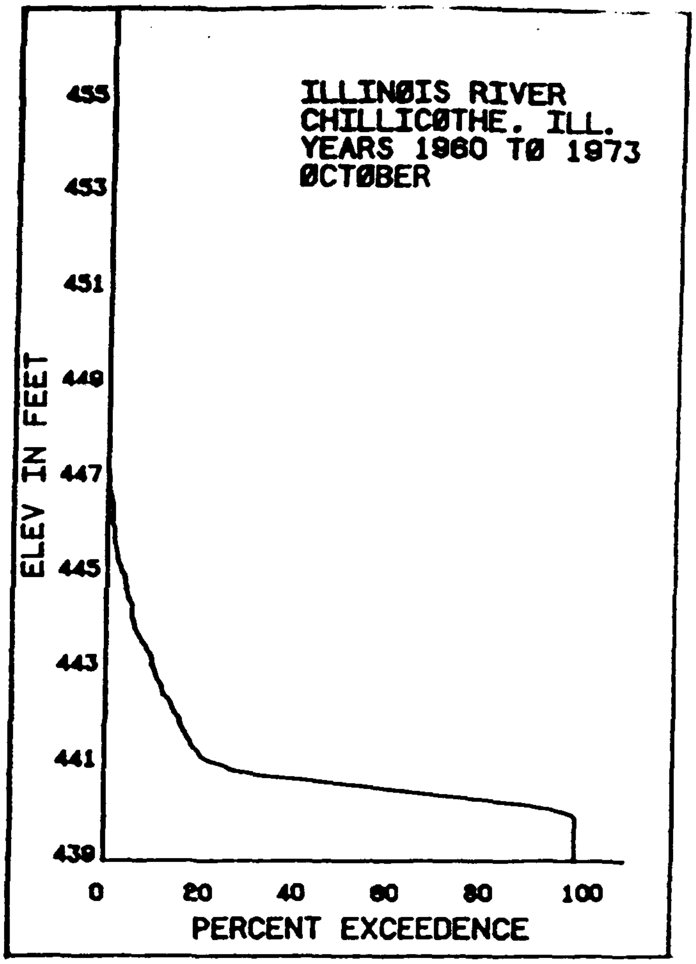
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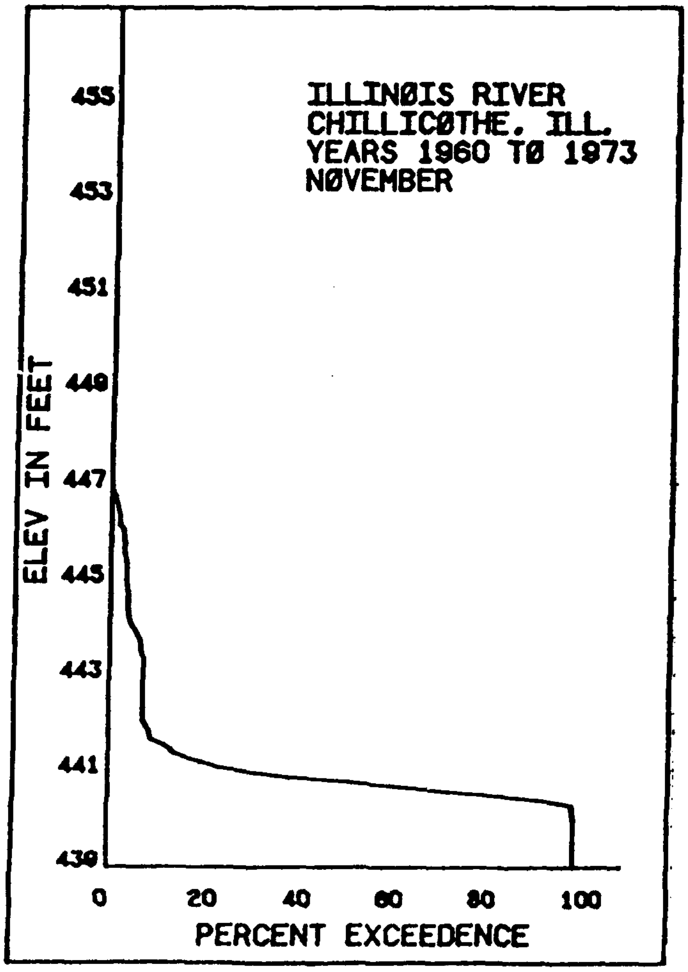
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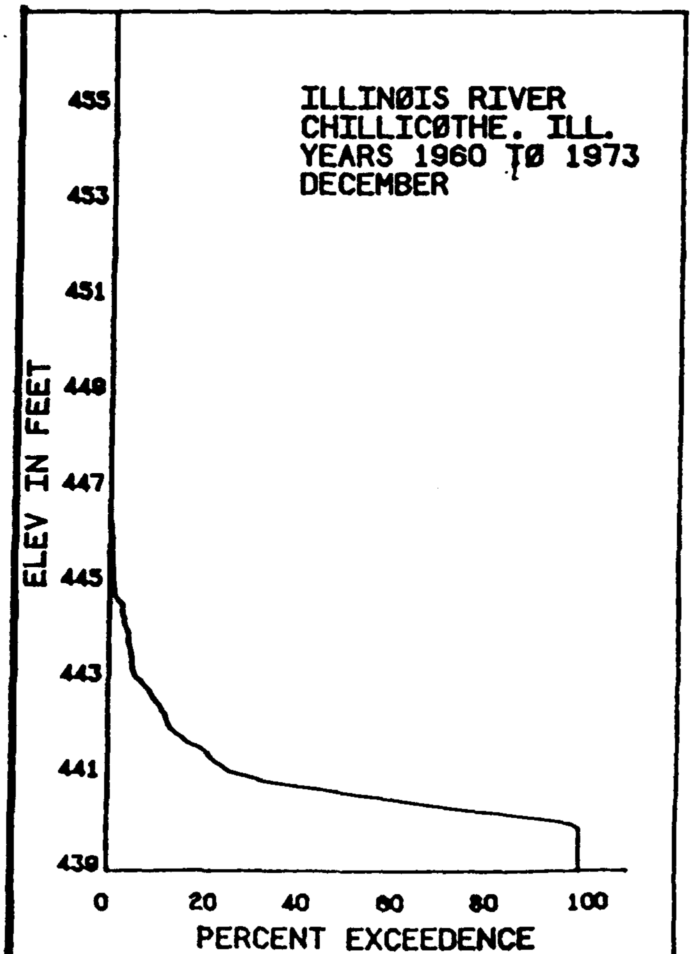
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ELEV IN FEET
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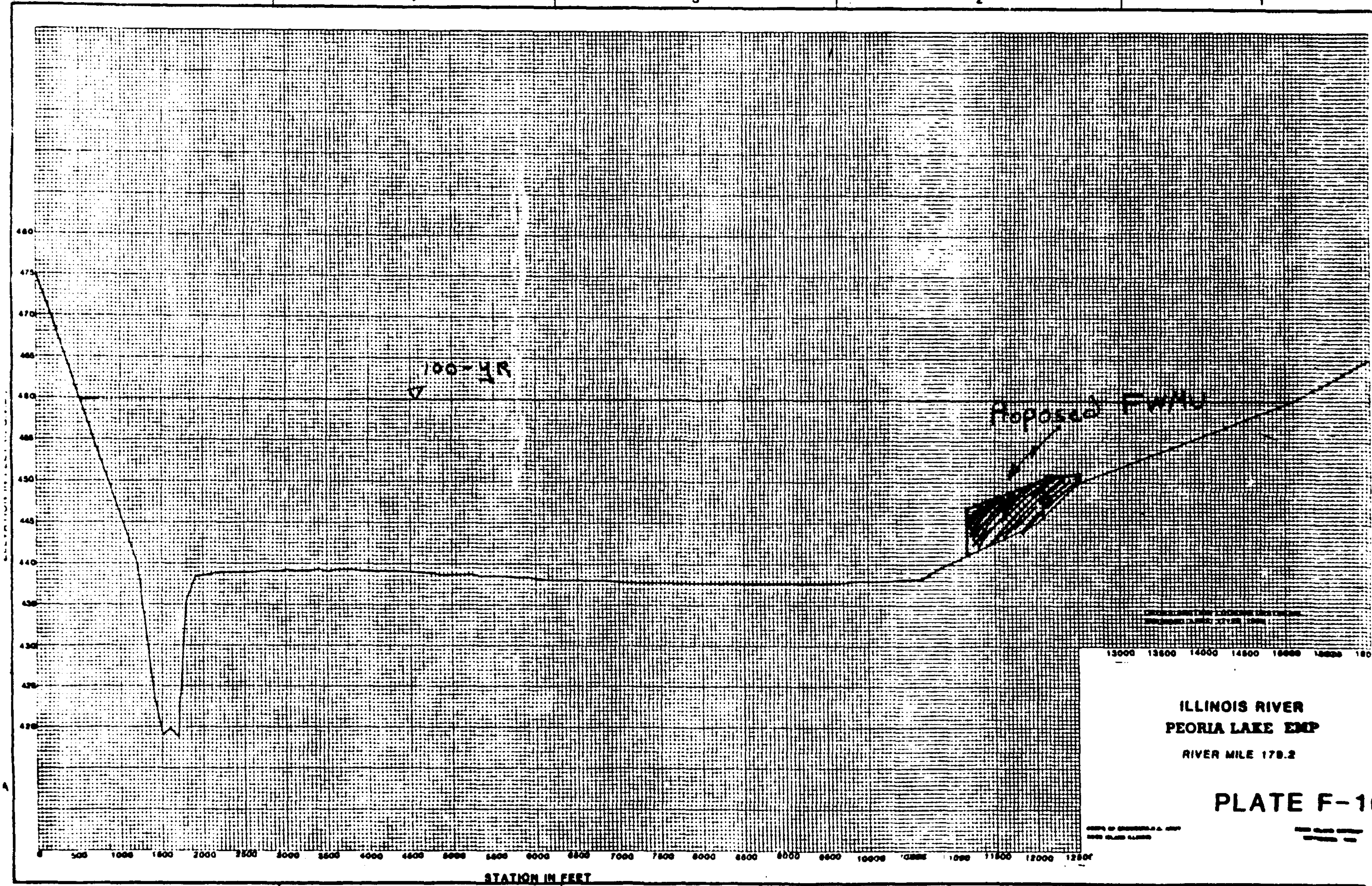
60
80
100
PERCENT EXCEEDENCE

PLATE F-9

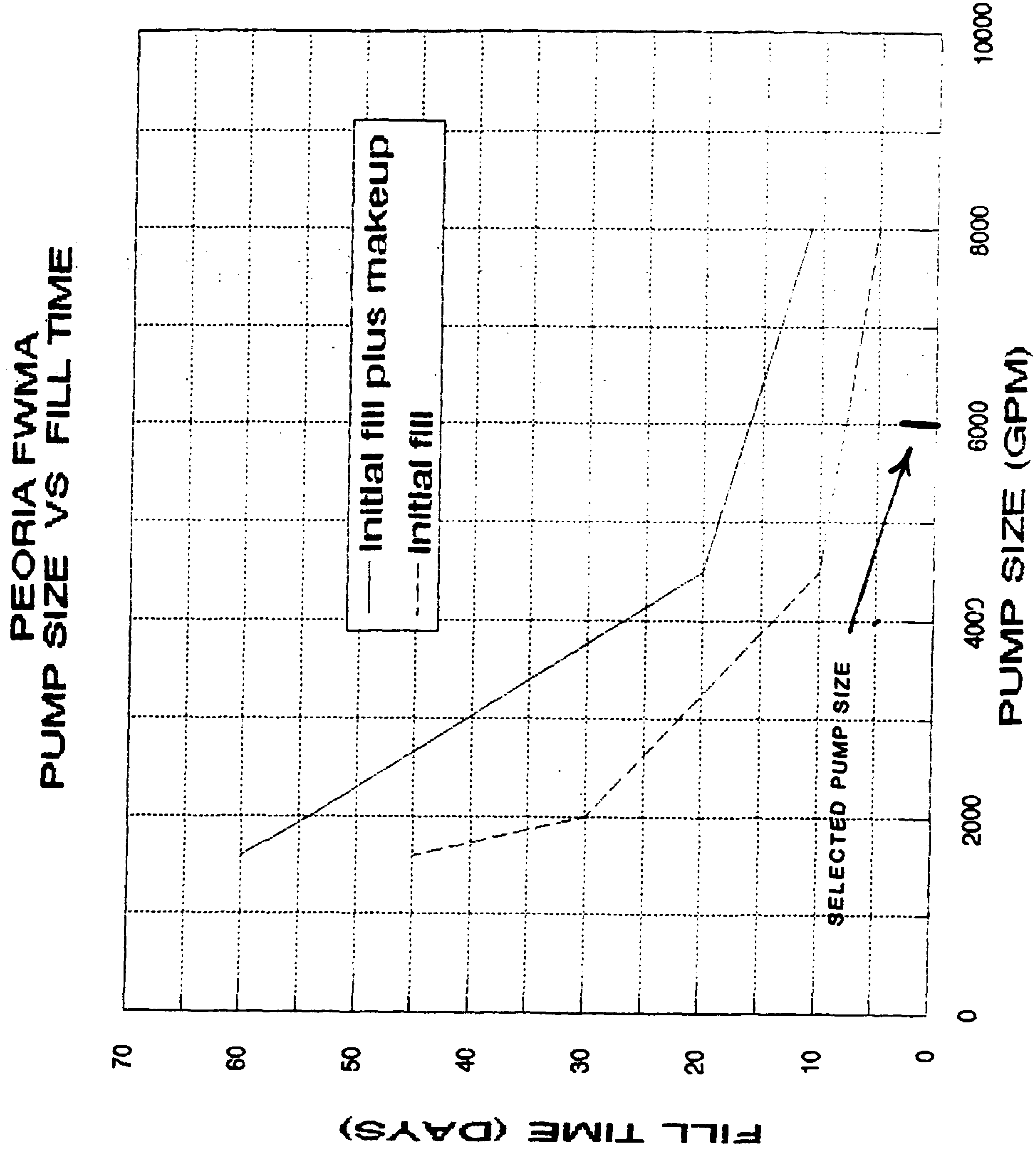


ILLINOIS RIVER

PEORIA LAKE EMP

RIVER MILE 179.2

PLATE F-10



PEORIA FWMA
PUMP SIZE VS FILL TIME
Initial fill plus makeup
Initial fill
SELECTED PUMP SIZE
PUMP SIZE (GPM)
0
2000
4000
6000
8000
10000
FILL TIME (DAYS)
0
10
20
30
40
50
60
70

PLATE F-11

DESIGN FOR CONSTRUCTION OF PEORIA LAKE BARRIER ISLAND AND EAST RIVER DREDGED MATERIAL PLACEMENT

A P P E N D I X G

BY
R. E. LEACH
J. FOWLER
U.S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION
VICKSBURG, MISSISSIPPI

UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
DEFINITE PROJECT REPORT
WITH INTEGRATED ENVIRONMENTAL ASSESSMENT (R-6F)

PEORIA LAKE ENHANCEMENT
PEORIA POOL, ILLINOIS WATERWAY, RIVER MILES 178.5 TO 181
STATE OF ILLINOIS

APPENDIX G
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PEORIA LAKE ENHANCEMENT
PEORIA POOL, ILLINOIS WATERWAY, RIVER MILES 178.5 TO 181
STATE OF ILLINOIS

APPENDIX G
DESIGN FOR CONSTRUCTION OF PEORIA LAKE BARRIER ISLAND AND EAST RIVER DREDGED MATERIAL PLACEMENT

G-1. INTRODUCTION.

The Peoria Lake Enhancement project is part of an Upper Mississippi River System Environmental Management Program (EMP). Numerous agencies, both Federal and State, that have been or are involved in the conception, design, acceptance, and future maintenance of this EMP project are the: (1) U.S. Army Engineer District, Rock Island; (2) Illinois Department of Conservation; (3) Illinois Environmental Protection Agency; (4) U.S. Environmental Protection Agency; (5) U.S. Fish and Wildlife Service; (6) INHS; (7) ISWS; and (8) U.S. Army Waterways Experiment Station. The total project will incorporate a Forested Wetland Management Unit, will reestablish flow in the East River for fisheries benefits, and will form a barrier island to help restore and improve aquatic habitat.

G-2. SITE DESCRIPTION.

a. General.

The barrier island and East River channeling projects are located north of Peoria, Illinois, on the upper reaches of Peoria Lake, as shown in figure G-1. Peoria Lake, constructed approximately 50 years ago, has been retaining sediment from the Illinois River and from local erosion this entire time. The 1.3-mile-wide upper reach of the lake is filling in first. Water levels near the proposed construction area range from .5 to 3 feet deep. The sediment is composed of soft clays and silts overlying the original stiff clays.

Construction of the island will start near the East River embankment on the west and will continue south along the previous high ground just west of the old Goose Pond area, for a total distance of approximately 1.3 miles. The East River channel will be reopened from the start of the barrier island, north through the silt plug, and into the present channel, for a total distance of approximately 2,000 feet.

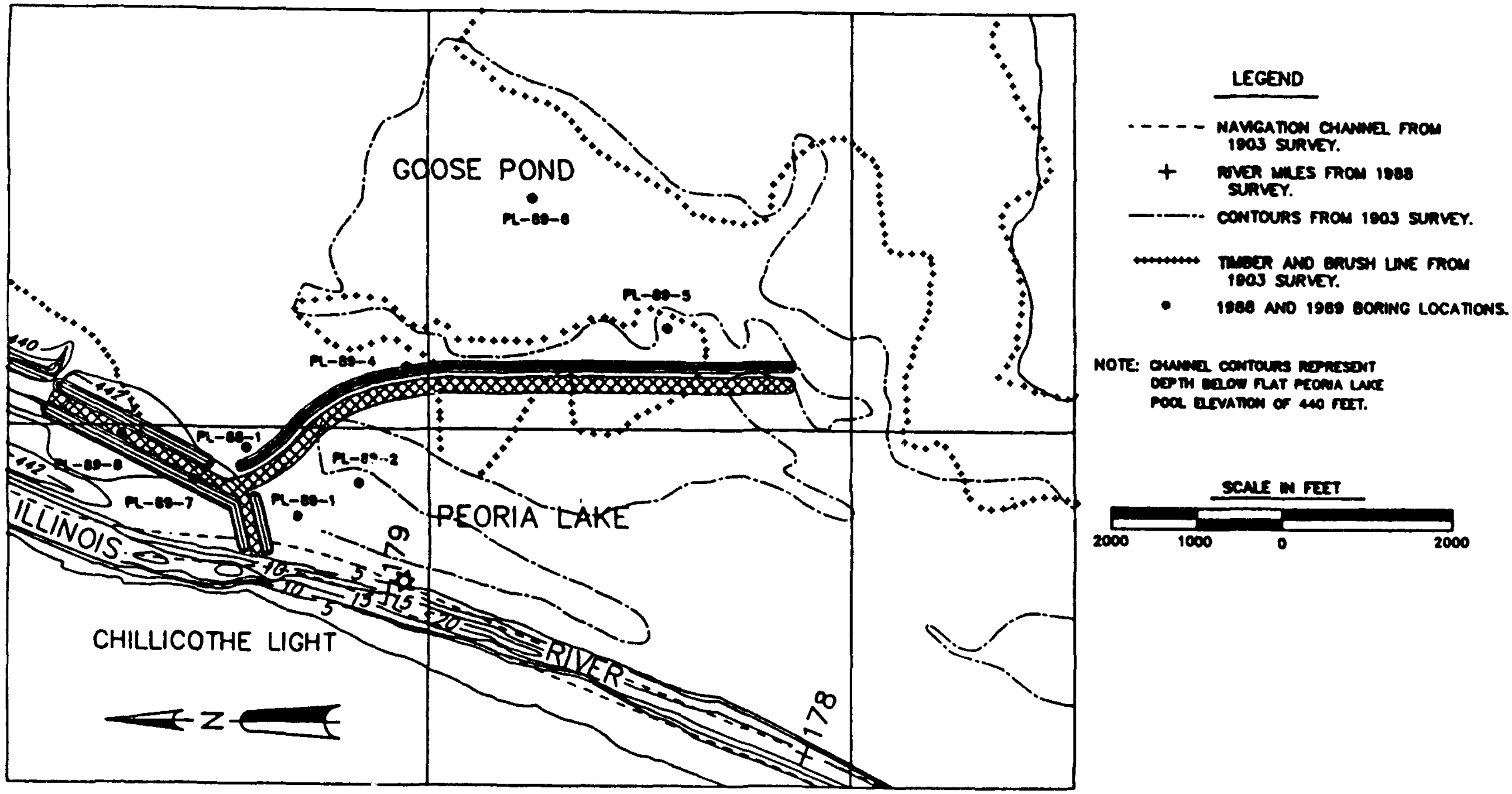


Figure G-1. Proposed Site Plan.

b. Field Exploration.

(1) Vane Shear Tests.

The Peoria Lake sediments are very soft, compressible soils. Obtaining undisturbed samples that can be used to conduct laboratory strength tests would have been unsuccessful. Therefore, a vane shear device was used to obtain the undrained unconsolidated shear strength at the six borings shown in figure G-1. The vane shear test consists of inserting a 4-bladed vane into the undisturbed soil and rotating it, according to ASTM standards, from the surface to determine the torque required to fail a cylindrical surface around the vane. The measured undrained unconsolidated shear strength in pounds per square inch (psi), S_u (measured), is related to the measured torque, T, by the following relationship:

S_u (measured) = 3T / 28 (pi) r^3

pi = 3.14
r = radius of the vane, in.
This equation applies only for a height to width vane blade ratio of 2.

S_u (design) = S_u (measured) x lambda

The design shear strength, S_u (design), is obtained by multiplying the measured shear strength by a correction factor, lambda, (Bjerrum, 1972), related to the plasticity index, PI, of the soil obtained from laboratory tests. For this design, the shear strength units will be presented as pounds per square foot (psf).

Vane shear measurements were taken at 2-foot increments starting at the surface of the sediments in Peoria Lake and going to the point of refusal for the vane. The results of the shear strength measurements at Peoria Lake are shown in table G-1. The last measurement was always the refusal depth for a particular location. The larger 3-inch vane, commonly used in the softer soil, reached refusal depth at a maximum of 13 feet and a minimum of 8.5 feet. Data from borings PL-89-1, 2, 4, 5, and 6 were obtained while there was ice covering the lake, allowing personnel to operate from a substantial flat surface. Data shown for boring 7A (PL-88-1) were obtained at an earlier date while leaning off the side of a boat. Although somewhat erratic, the data for 7A are shown to better define the subsurface soil profile. The measurement at a depth of 6 feet at boring 7A should be considered erroneous due to the changing of the vane size and the awkward data collection procedure. The vane shear measurements ranged from 20 to 85 psf for the soft fat clay, from 228 to 706 psf for the stiff clay, and from 706 to 1000 psf at refusal.

TABLE G-1
BARRIER ISLAND
SHEAR STRENGTH MEASUREMENTS

BORING	DEPTH FT	1* IN-LBS	LL	PL	PI LAYER1	PI LAYER2	PIavg	LAMDA	Su PSF
PL-89-1	1	70					43	.84	86
	3	238					28	.93	323
	5	475					28	.93	645
	7	442	37	26		11	28	.93	600
	8.5	600						.93	815
	13		47	25		22			
PL-89-2	1	40					43	.84	49
	3	50					43	.84	61
	5	62					43	.84	76
	6		86	37	49				
	7	272					28	.93	369
	9	400					28	.93	543
	10		58	30		28			
	11	375					28	.93	509
	13	492					28	.93	668
PL-89-4	2	40					43	.84	49
	4	55	67	32	36		43	.84	67
	6	270					28	.93	367
	8	520	67	31		36	28	.93	706
PL-89-5	3	25					43	.84	31
	4								
	5	55					43	.84	67
	7	220					28	.93	299
	8		51	18		33			
	9	280					28	.93	380
PL-89-6	3	21					43	.84	26
	5	35					43	.84	43
	7	62					43	.84	76
	9	168	101	40	61		28	.93	228
	11	210	51	24		27	28	.93	285
	13	590					28	.93	801
PL-88-1	.8	40 **					43	.84	21
	2	80 **	50	24	26		43	.84	41
	4	270 **					28	.93	154
	4.5	600 **	71	29		42	28	.93	343
	6	30					28	.93	107
	8	175	46	19		27	28	.93	622
	10	125					28	.93	444
	10.5	315					28	.93	1119

* Using a 4" dia. vane
** Using a 2" dia. vane

(2) Soil Sampling.

Two methods of sampling were used to collect jar samples: a piston tube (Hvorslev) sampler and auger samples. To obtain samples using the piston tube sampler, a sample tube is pushed into the ground while a piston inside the tube is held at a constant height, creating a vacuum on the sample. The vacuum allows the soft samples to be brought to the surface without sample loss or inadvertent mixing with free water which is often above the soft sediments. One drawback to the hand-operated piston sampler is that a dense soil layer could cause refusal and no sample could be obtained. Tube samples are undisturbed soil samples of a known volume that can be tested in the laboratory to obtain in situ soil properties needed for stability design. Properties obtained or calculated from the laboratory data include soil density, void ratio, saturation, and natural water content. All the data used in this report were determined using the tube samples. The second method, using an auger to collect soil samples, could work for all but the softest material which might slide or flow from the auger. Auger samples only can be used to determine geologic classification, to obtain water content, and to obtain Atterberg limits of the soil, but these soil properties are not sufficient to calculate the other properties needed for design. For this reason, the auger samples were only used as comparative data. Collecting samples from the auger requires experience and care from the personnel involved in both the augering and in the trimming of the excess material that may be contaminated with other sediment or that may have trapped surface water as the sample is brought out of the hole.

c. Laboratory Tests.

Soil properties other than shear strength can be used to generally estimate strength parameters or changing conditions such as layering. Some of the properties that can be obtained in the laboratory from disturbed samples collected in the field are liquid limit (LL), plastic limit (PL), and natural moisture content (w). The plasticity index (PI) obtained from the laboratory results is needed to adjust the vane shear strengths. The results obtained from the samples taken in the same locations as the vane shear tests (figure G-1) are shown in table G-2. Laboratory soil classifications also were determined to verify field observations, and the results are shown on the borings logs in figures G-2, 3, and 4. The laboratory tests indicated the following ranges for the samples tested: LL (37 - 101), PL (18 - 40), PI (11 - 61), and w (28 - 191).

d. Subsurface Description.

The results of the field exploration and laboratory tests were compiled and subsurface profiles along the barrier island and the East River alignments were generated using all the information gathered. The profiles are shown in figure G-5.

TABLE G-2
BARRIER ISLAND
SOIL PROPERTIES

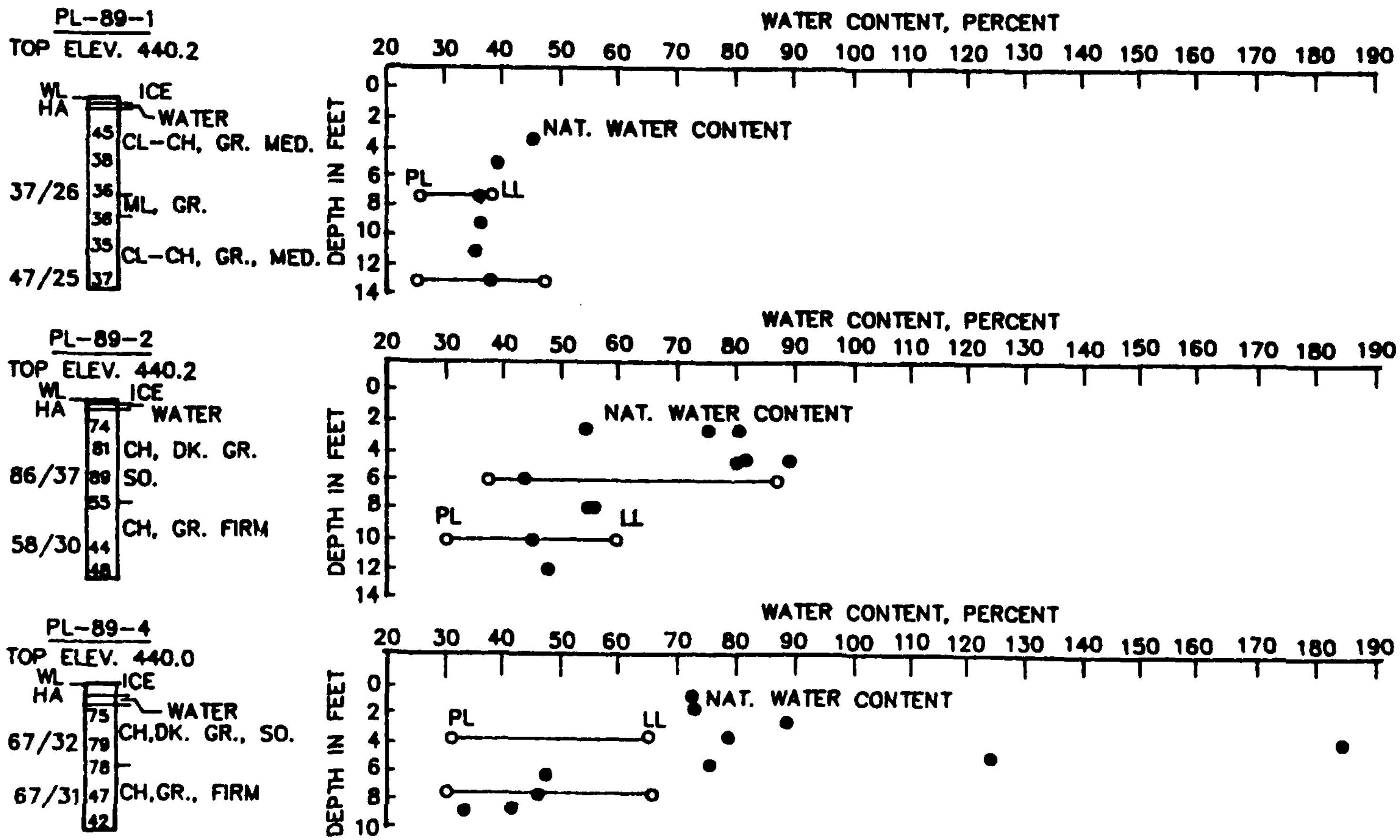
Total Volume 155.46
Spec Gravity 2.70
METRIC CONST .02

DATE	SAMPLE NO.	DEPTH	GAMMA WET PCF	GAMMA WET G/CC	GAMMA DRY PCF	GAMMA DRY G/CC	WATER CONTENT
	PL-89-2, T-1	1.0 - 1.5	104.50	1.66	60.00	1.08	.54
	T-2	2.0 - 2.5	93.70	1.49	51.50	.82	.82
	T-3	4.0 - 4.5	94.50	1.50	52.40	.83	.80
	T-4	6.0 - 6.5	111.50	1.77	77.90	1.24	.43
	T-5	8.0 - 8.5	103.90	1.65	65.50	1.04	.59
	PL-89-4, T-1	1.0 - 1.5	92.20	1.47	52.80	.84	.75
	T-2	3.0 - 3.5	91.30	1.45	47.70	.76	.91
	T-3	5.0 - 5.5	82.50	1.31	36.10	.57	1.29
	T-4	7.0 - 7.5	107.30	1.71	71.70	1.14	.50
	T-5	9.0 - 9.5	118.40	1.88	88.00	1.40	.35

CONTINUED

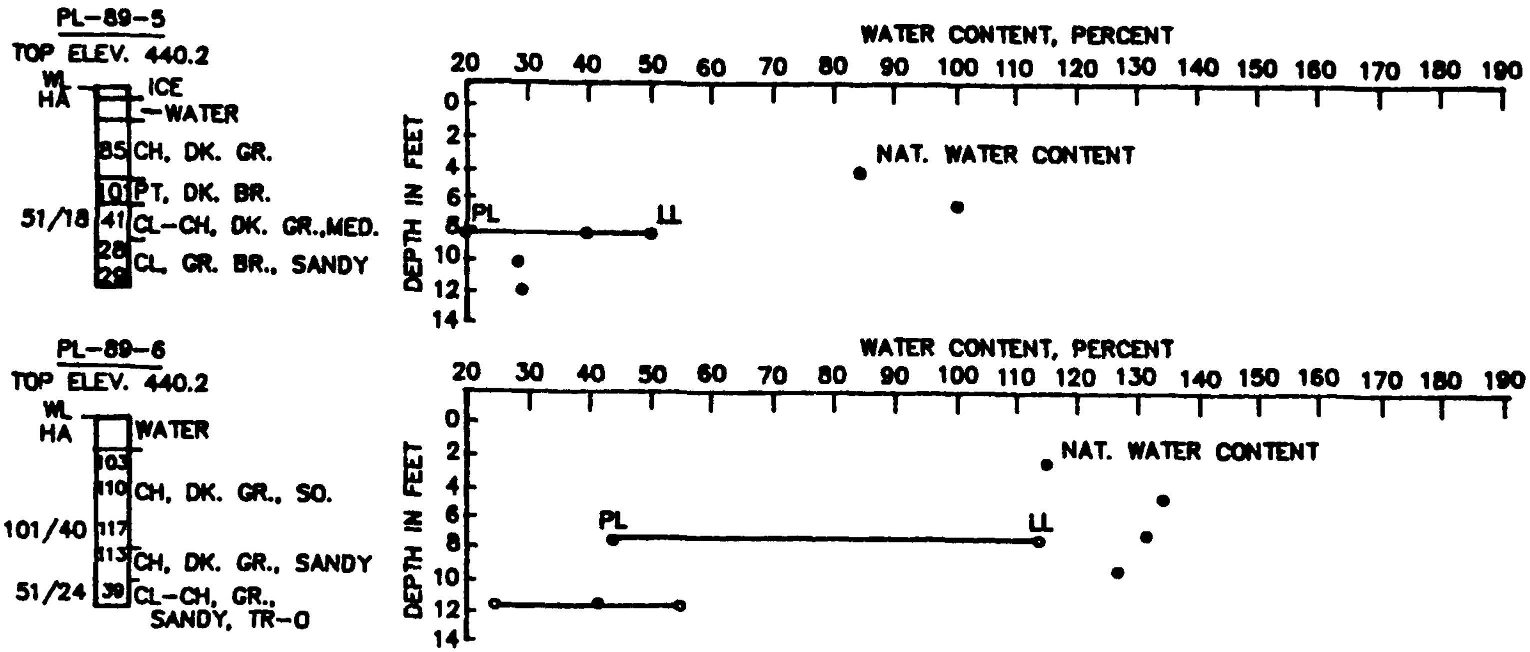
TOTAL WEIGHT GRAMS	WEIGHT OF SOIL GRAMS	WEIGHT OF WATER GRAMS	VOLUME OF WATER CC	VOLUME OF VOIDS CC	VOLUME OF SOLIDS CC	VOID RATIO	SATURATION	POROSIT
258.30	167.73	90.57	90.57	64.89	62.12	1.04	.97	.60
231.61	127.26	104.35	104.35	51.11	47.13	1.08	.96	.70
233.59	129.77	103.82	103.82	51.64	48.06	1.07	.97	.69
275.61	192.73	82.87	82.87	72.59	71.38	1.02	.99	.54
256.82	161.52	95.30	95.30	60.16	59.82	1.01	1.00	.60
227.90	130.23	97.67	97.67	57.79	48.23	1.20	.91	.69
225.68	118.16	107.52	107.52	47.94	43.76	1.10	.95	.72
203.92	89.24	114.68	114.68	40.78	33.05	1.23	.94	.79
265.23	176.82	88.41	88.41	67.05	65.49	1.02	.99	.56
292.66	216.79	75.88	75.88	79.58	80.29	.99	1.01	.48

CONCLUDED



NOTE: See legend on Figure G-4.

FIGURE G-2. Barrier Island Boring Logs and Laboratory Test Results.



NOTE: See Legend on Figure G-4.

FIGURE G-3. Barrier Island Boring Logs and Laboratory Test Results.

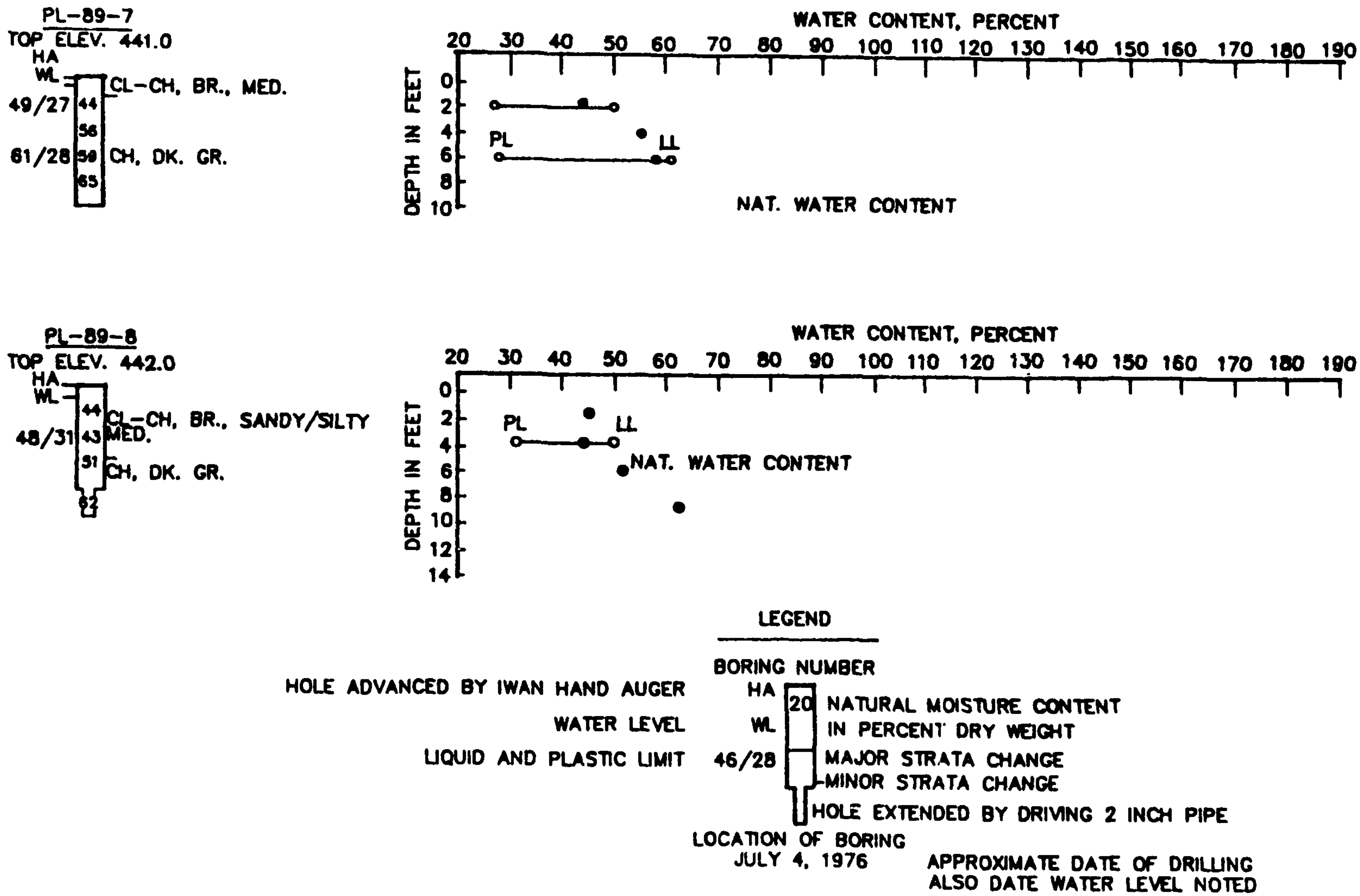
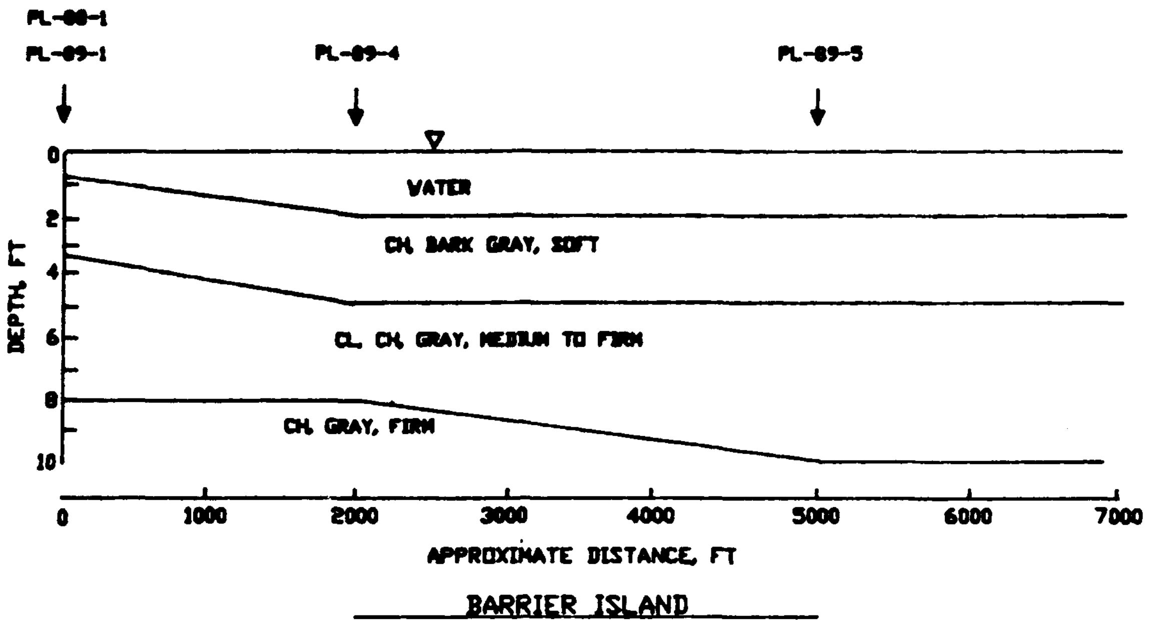


FIGURE G-4. East River Boring Logs and Laboratory Test Results.



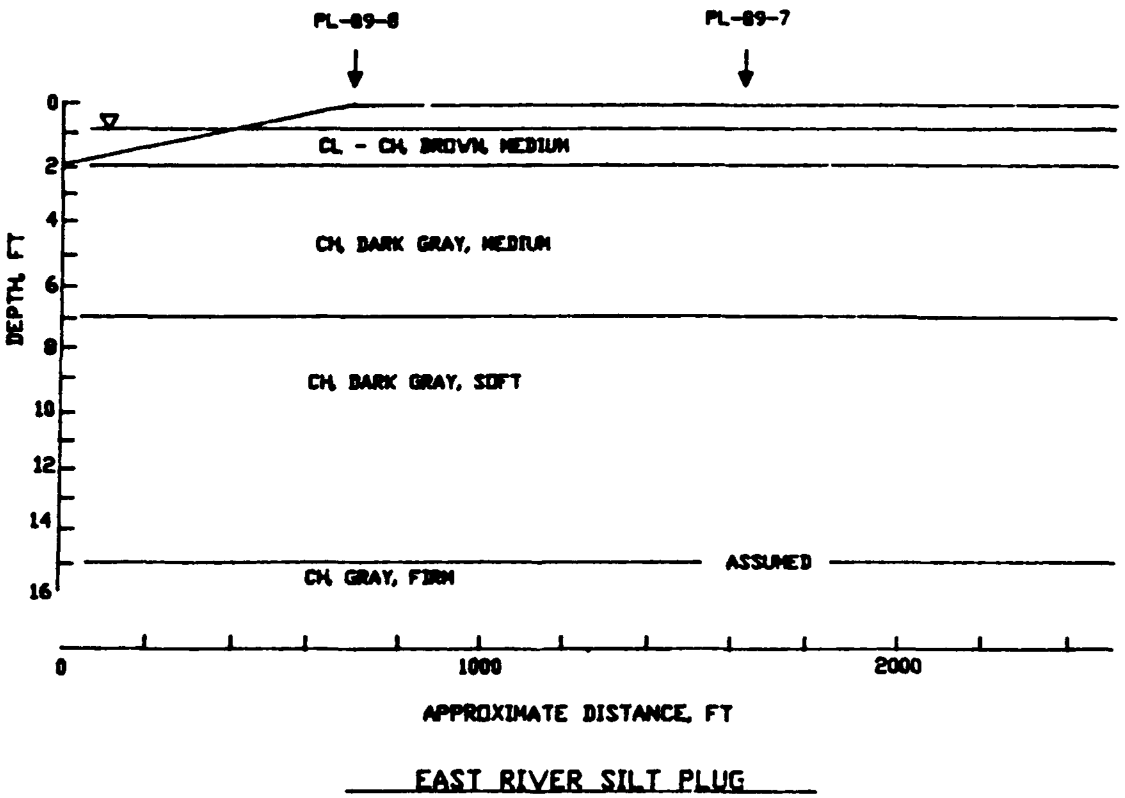


FIGURE G-5. Subsurface Profiles Along the Barrier Island and the East River.

(1) Barrier Island.

The barrier island starts on or near the East River embankment and should have properties at that point similar to soil boring location 1, i.e., less than 3 feet of soft fat clay starting within 6 inches of the water surface and graduating into a medium clay at 3 feet and into a stiffer clay at 5 feet. Soil borings 2, 4, 5, and 6 were placed to determine a possible alignment for the island and although only one boring was on the final alignment, the subsurface profile in each boring was similar enough that a general profile could be drawn. The profile shows from 1 to 2 feet of water, then a soft fat clay down to 5 feet, and finally a mixture of firm fat clay with some lean clays down to the depth of the borings. The layering on the profile was determined from an evaluation of material type, material properties, and vane shear strengths. Because successful construction is dependent on strengths attained in the embankment, the vane shear strengths were relied on more heavily to establish the final layering profile. The strengths are assigned to the layers and the layers then are used as the strength profiles for stability calculations. After the layers were established and it was determined that the soils found in the different borings were similar, the soil properties were averaged to obtain a single set for each layer. The following is a list of the soil properties determined for the material layers:

	S_u, psf	LL	PL	PI	w (%)
Soft clay	50	76	33	43	90
Stiff clay	320	54	25	29	41
Foundation	600	54	27	27	41

(2) East River.

The least amount of information was gathered along the alignment of the East River. Although less information does not provide as accurate an evaluation of existing soil properties as would be desirable, the material will be placed on the present embankment which makes the layering a less important design factor than the "as placed" strength which is needed to calculate the height of the new placement area. A series of laboratory tests were run on jar samples to determine LL, PL, w, and estimates of layering and strengths were based on these data and the barrier island data. The profile for the East River starts approximately 1 foot above the water surface of the river and ranges from a brown, medium lean clay with some sand and silt (location PL-89-8) to a gray, fat clay (location PL-89-7). The soil properties for both materials appear to be similar to a depth of 6 to 7 feet. The gray, fat clay then extends to the bottom of both borings, 9 feet. The water table was the river elevation. The following is a list of soil properties determined for the soil layers:

	S_u, psf	LL	PL	PI	w (%)
Stiff clay	320	48	29	19	50
Fat clay	160	61	28	33	64
Foundation	600	54	27	27	41

G-3. FOUNDATION ANALYSIS

a. Proposed Construction Geometry.

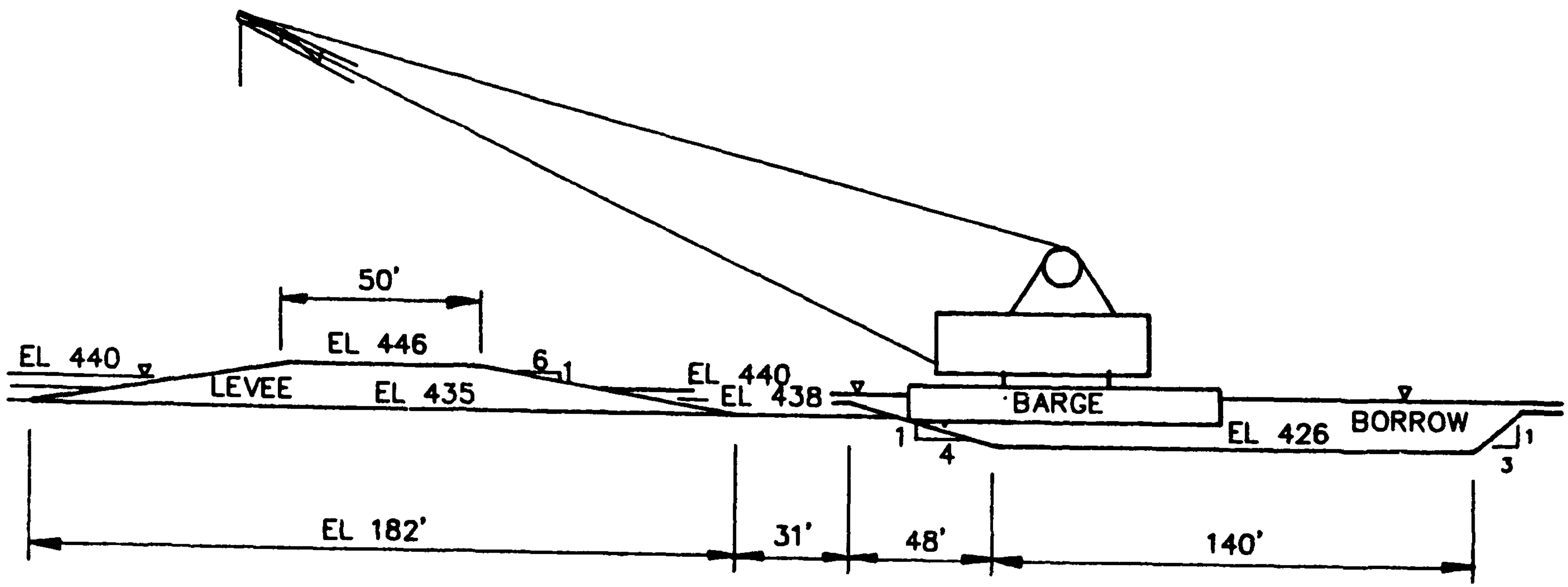
(1) Barrier Island.

The original concept for the geometry of the proposed barrier island was that it would have a crest width of 50 feet and a height of 6 feet above the normal pool, and that it would be built from site excavated material. No limits were placed on the borrow area, but economics, volumes, and stability were certainly the governing factors. The final geometry (figure G-6) incorporates the 50-foot crest and the 6-foot height above normal pool. The assumption was made that a portion of the soft fat clay to an approximate depth of 5 feet below the water table would be displaced by the borrow material (see "Bearing Capacity") and that the resulting slopes for the stability analysis would be 1V:6H. The borrow area was held a minimum of 30 feet from the final toe of the island for stability. The geometry of the borrow area, 135 feet wide and 15 feet below the pool level, was dictated by the reach of the clamshell barge and the depth needed to excavate competent material. Economics and hydraulic considerations were used to set the limit on the length at 1.3 miles.

The geometry of the dredge placement areas for the channel excavation leading into the barrier island was assumed to be similar to the East River geometry, as shown in figure G-7. For the proposed geometry, the excavated material would only require a final height of 1 foot above water level for placement of the total volume. This low section (1 foot above water) is compatible with the hydraulic characteristics reported in Appendix E - Hydrology and Hydraulics.

(2) East River Dredging.

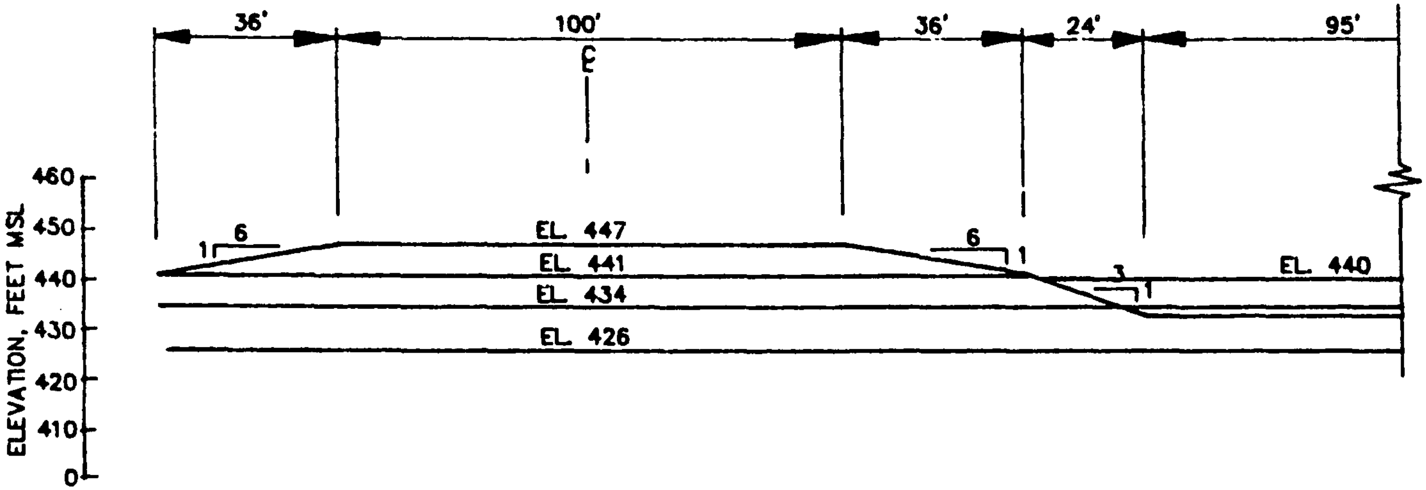
The preliminary dredge width for the East River was proposed to be 200 feet and 6 to 7 feet deep. A review of the soil properties in the channel showed that the upper layer of soil in the silt plug has similar strength, 320 psf, to the material to be used for the barrier island but that the strength decreases to 160 psf for the layer below 6 feet. Placement of the dredged material to elevation 437 using the lower strength material will be more difficult and will require more area for placement. To avoid having to place material over a wide area of the embankment, the bottom width was decreased to 95 feet, as shown in figure G-7. The depth dredged would still be 7 feet below the water surface, but the excavated material could be placed on both sides of the channel in 170-foot-wide clearings, and the



NOTE: SEE SOIL LEGEND ON FIGURE 8.

PEORIA LAKE E.M.P.

FIGURE G-6. Proposed Geometry for the Barrier Island.



NOTE: Figure G-7 is symmetrical.
See soil legend on Figure G-10.

FIGURE G-7. Proposed Geometry for the East River Excavation.

natural vegetation, grass, and trees would not have to be removed. The excavated channel will be approximately 2,000 feet long.

b. UTEXAS2 Slope Stability Program.

Slope stability analyses were made using the UTEXAS2-University of Texas Analysis of Slopes-Version 2 (I0029) available in the Corps time-sharing library. The UTEXAS2 program is used to analyze slopes using four methods and will calculate a safety factor for a prescribed shear surface or will search for the critical shear surface. The noncircular (wedge) analysis using the CE Modified Swedish side-force inclination assumption was chosen for this study because the common mode of failure in this type of construction is sliding on a weak layer.

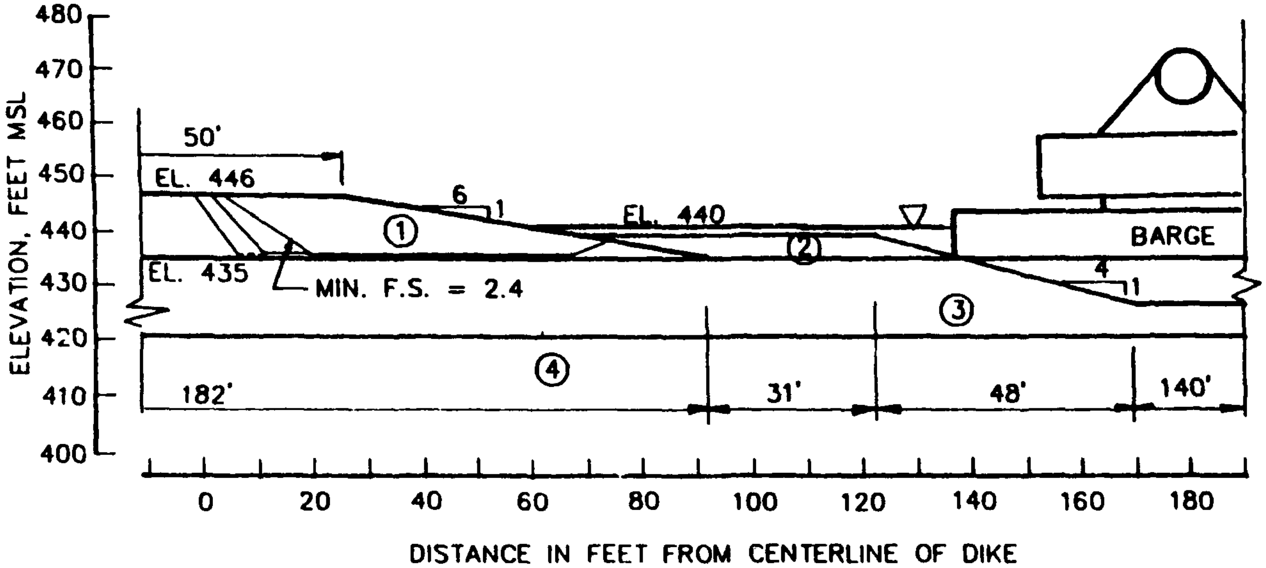
c. Peoria Lake Barrier Island.

(1) Slope Stability.

After determining the soil properties and the construction geometry, strength parameters were assigned as shown in figure G-8. The vane shear strengths were used for the layers that will not be disturbed by borrowing. The strength chosen for the excavated material was assumed based on experience gained from other similar projects. The slopes on the island (1V:6H) were assumed based on the strength of the borrow material and placement techniques. For the borrow area, the 1V:3H slope is expected for soft material excavated under water and the 1V:4H slope is needed to maneuver the barge. Using the wedge slope stability method and the assigned strengths, analyses were made to evaluate the stability of the final construction geometry as shown in figures G-8 and 9. The minimum factor of safety found was 2.4, which is shown in figure G-8 with the other safety factors and shear surfaces that were determined. The UTEXAS2 program was run in the search mode and numerous other surfaces were calculated but only the final results of these particular runs are considered relevant. While these factors of safety indicate that good stability exists for all cases analyzed, it should be noted that these calculations are for "after construction" stability and the actual construction may require constructing these sections in stages, as will be discussed hereinafter.

(2) Bearing Capacity.

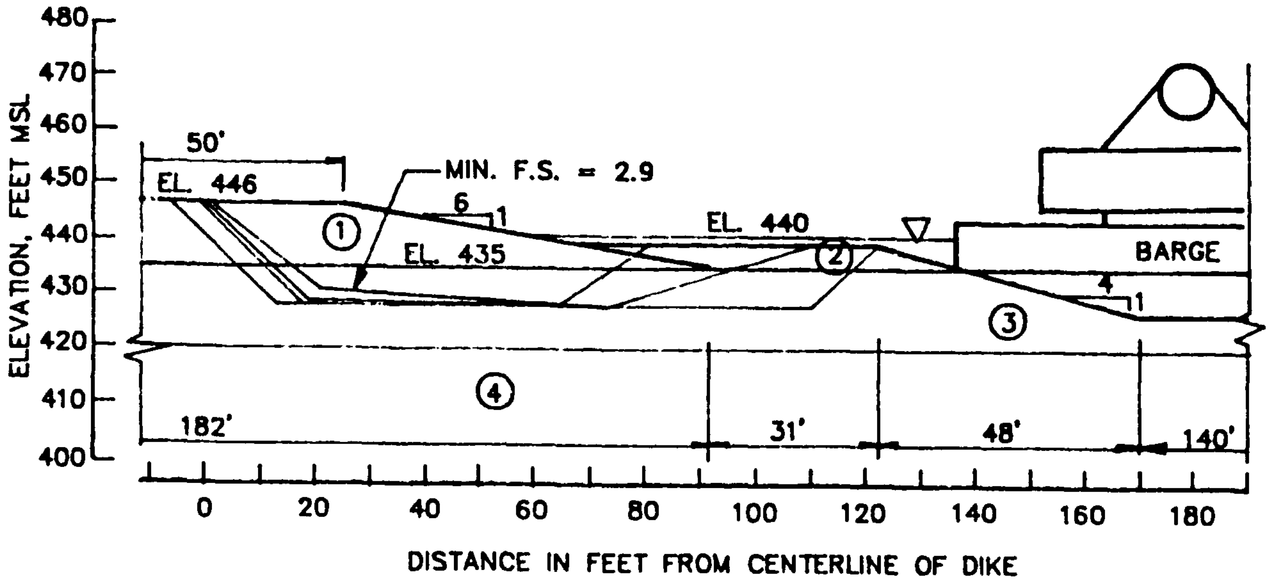
The barrier island was assumed to be a shallow footing and the design was checked for a bearing capacity failure. A bearing capacity check is obtained by comparing the foundation soil strength against the pressure exerted by the structure on the soil. By determining the height of the material needed to equal the soil strength, a safety factor of 1 is applied and some input is obtained relating to construction sequence. The results are for the properties shown in figure G-8. The height achieved before failure for soil 2, 2.7 feet, was computed using pressures exerted assuming soil 3 would be placed in the island. A sample computation detailing the 2.7 feet calculation is shown in figure G-17. Material placed 2.7 feet high would barely clear the water before soil 2 would fail and, therefore,



LEGEND

	c	Ø	δ
1 EMBANKMENT	160	0	110
2 SOIL 2	50	0	93.5
3 SOIL 3	320	0	110
4 SOIL 4	600	0	110

FIGURE G-8. Stability Analysis for Barrier Island.



See soil legend on Figure G-8.

FIGURE G-9. Stability Analysis for Barrier Island.

it was assumed that all the soil 2 would be displaced immediately and that the foundation material would be the soil 3 layer. If soil 3 material were then placed on a soil 3 foundation, theoretically the island could be built 15+ feet high or 10 feet above the water, but the limiting factor then would be the strength of the material, soil 1, after it is placed in the island. Using the reduced strength of the island material and even assuming buoyant weight below the water line, the maximum height that soil 1 could be placed would be 10.3 feet (5 feet above the water). Although several assumptions are made to compute bearing capacity failure, the numbers shown are for a safety factor of 1 and realistically it can be assumed that the island cannot be constructed in only 1 pass, i.e., placed to a height of 6 feet above the water line. The island material may have to consolidate, desiccate, and drain at least 2 months to gain strength before a final pass is made to bring the island up to the specified 6 feet above water. A bearing capacity check was made for the final geometry of the island, assuming soil 1 material in the island and soil 3 material as the foundation, and the results are shown in figure G-17. The factor of safety of 2.8 was acceptable for the assumptions made in the calculations.

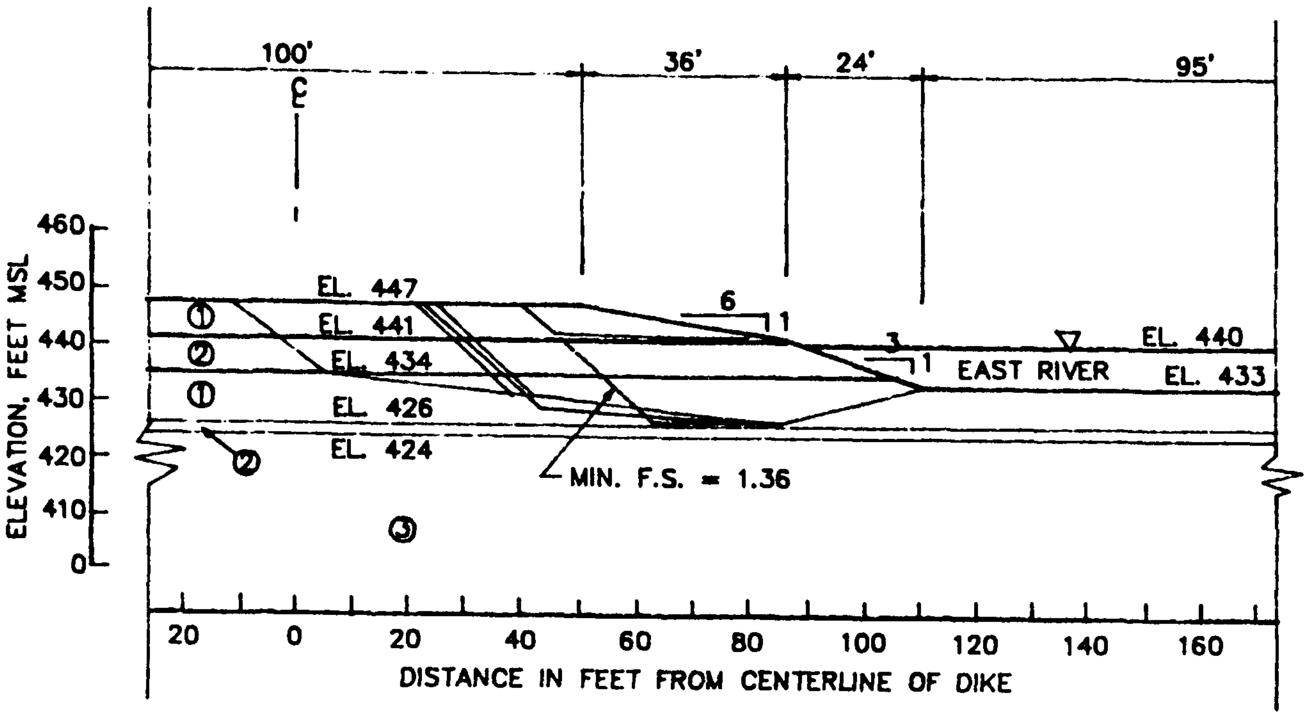
(3) Settlement.

Time-dependent settlement analyses were made for the island constructed to 6 feet above the water to estimate the long-term consolidation settlement that should be expected to occur. Assuming one-dimensional, vertical drainage consolidation, settlements were estimated to be less than 1 foot at the island centerline for the soil properties, as shown in figure G-8. These are long-term consolidation settlements and do not include settlement due to both shrinkage and decomposition of the island material. The time estimated to realize 50 percent of the long-term settlement was 1.5 years. These calculations are shown in figure G-18.

d. East River Dredging.

(1) Slope Stability.

Using measured and/or assumed soil properties and construction geometry, strength parameters and layering were established as shown in figure G-7. The laboratory soil test results were used to determine layers and to match similar materials with the results obtained from the borings completed in the area of the island. The minimum slopes for the dredge embankments were set at 1V:6H because it was not clear exactly how soft the material was in the silt plug. The borrow slopes, excavated underwater, should slough off to a 1V:3H. The wedge slope stability method and the assigned strengths were used to analyze the final construction geometry, as shown in figures G-10 and 11. The minimum factor of safety found was 1.36, as shown in figure G-10. While these factors of safety indicate adequate stability, it should be noted that these calculations are for "after construction" stability, and the actual construction may require placing these sections in stages.

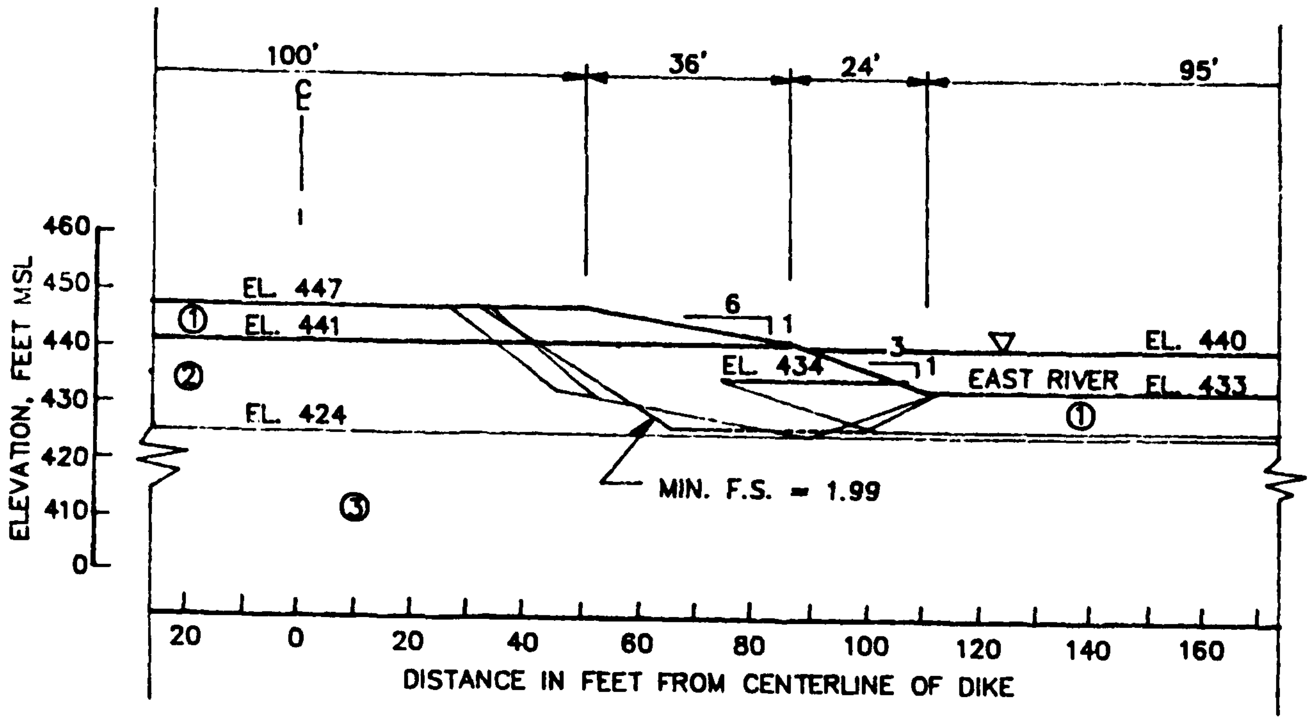


LEGEND

	c	ø	γ
① EMBANKMENT	160	0	110
② SOIL 2	320	0	110
③ SOIL 3	600	0	110

ASSUME EAST RIVER 95 FT WIDE

FIGURE G-10. Stability Analysis for East River.



For Soil Legend, see Figure G-10.
Assume East River 113 feet wide.

FIGURE G-11. Stability Analysis for East River.

(2) Bearing Capacity.

It was assumed that the material removed from the East River would possess a strength of 160 psf after placement. A strength of 160 psf was equivalent to soil 1 described for the barrier island and, therefore, the East River embankment construction was expected to be limited by the bearing capacity of this soil. The maximum height that soil 1 could be placed, 7.5 feet, was calculated assuming all the material would be placed above the water surface; thus, the total wet unit weight of the soil would be acting against the soil strength. Again it should be noted that the calculations were for a factor of safety of 1 and construction would need to be phased to compensate for any reduction in strength of the material.

(3) Settlement.

To calculate settlement, the embankment was assumed to be constructed to 6 feet above the natural embankment or 7 feet above the river level. Assuming one-dimensional, vertical drainage consolidation, long-term settlements were estimated to be less than 1 foot at the centerline of the new embankment as shown in figure G-18. These long-term consolidation settlements do not include settlement due to shrinkage or decomposition of the dredged material.

G-4. CONSTRUCTION MATERIAL ESTIMATES.

a. Dredging Volumes.

The dredging volumes for the barrier island were calculated assuming a 50-foot-wide crest, 11-foot height including material displaced to 5 feet below water, and 1V:6H slopes as shown in figure G-6. The actual volume per linear foot of material needed to build the island would be 47 cubic yards. If the placed material attained a density similar to the material being excavated, the borrow-to-fill volume ratio would be 1:1, but instead another 30 percent volume should be added to the placed material for loss of volume resulting from spreading, desiccation, and consolidation, increasing the volume to 61 cubic yards. If the island were 1.3 miles long, the total amount of borrow material needed would be 420,000 cubic yards.

The borrow area volumes were calculated assuming a 135-foot width at the bottom, 1V:3H slopes, and an excavation depth of 15 feet below the water surface, as shown in figure G-6. An average of 13 feet of borrow material below 2 feet of water would have to be excavated for a borrow volume of 83 cubic yards per linear foot or 570,000 cubic yards for 1.3 miles. It was assumed that most of the upper 3 feet of the dredged borrow material, if placed in the island, would be displaced by the stiffer, heavier borrow material placed later. Because 3 feet of the soft material would be displaced, this material is shown placed downstream of the borrow area and the usable borrow material is reduced to 61 cubic yards per linear foot, the value needed for the island.

Bulking of the borrow material (which was considered negligible) and spreading, desiccation, and consolidation of the placed materials were factors to consider in design and materials estimating and for very soft materials. These factors are difficult at best to estimate. The volumes calculated were for construction estimating and were considered worst case scenarios.

To reach the barrier island, the barge must dredge a channel from the Illinois River to the beginning of the island. The entrance channel does not have to be as wide or as deep as the island borrow area; therefore, the channel volume was calculated assuming a 7-foot minimum depth (below water), a 95-foot-wide bottom, and 1V:3H borrow slopes. Average water depth in the channel area was assumed to be 2 feet. For a channel 1,300 feet long, 26,000 cubic yards would have to be excavated.

To open the East River, a channel 2,000 feet long would have to be dredged up-river from the end of the barrier island through the silt plug. A channel which would satisfy any hydraulic or environmental concerns was proposed to be 95 feet wide at the bottom, as shown in figure G-7. Approximately 7 feet of water was needed to float the barge, and the silt plug averages 1-foot elevation above water; therefore, 8 feet of soil will have to be moved. The slopes should slough at 1V:3H. The East River excavation will, for this geometry, require moving 70,000 cubic yards of material. To close a cut in the east bank of the East River near the north end of the 2,000-foot dredged channel would require another 8,000 cubic yards.

The total volumes that would be excavated for the island, the entrance channel, and the East River are as follows:

Barrier Island (final geometry)	420,000 cubic yards
Barrier Island (spoil material)	150,000 cubic yards
Access Channel	26,000 cubic yards
East River Channel and Cut Closure	78,000 cubic yards
TOTAL	674,000 cubic yards

b. Geotextile Fabric Reinforcement Alternative.

An evaluation was made to determine if the use of geotextile fabric placed on top of the lake sediments could help to reduce the amount of borrow material needed and be cost effective. If it is assumed that the fabric contains the 3 feet of soft material that would have been displaced, then the total borrow volumes for the 1.3-mile project could be reduced by 161,000 cubic yards. The fabric also would eliminate some of the spreading that would occur during placement of the island material and would help to stop some of the small slip failures that occur during this type of construction. Although savings from material spreading can not be measured, it is estimated that a 10 percent savings, or 42,000 cubic yards, may be realized. Total material savings due to fabric placement would be approximately 200,000 cubic yards for the 1.3-mile island.

It is recommended that a 1,000-foot trial section be built using fabric placed directly on top of the lake sediment, as shown in figure G-12. The fabric at this elevation would be approximately 60 yards wide, for a total of approximately 20,000 square yards of cloth in the trial section. If fabric is purchased at $3 per yard, the cost would be $60,000. For a 1,000-foot section, savings in borrow volume would be 30,000 yards, which, at $2 per yard, also would be $60,000. Although costs are similar, savings on material volumes from less spreading, fewer small slip failures, and unexpected soft spots in the lake sediments would expedite construction, minimize the mud wave, and provide a more favorable cost ratio. The island also would have a stronger foundation to support loading due to further construction.

Active lateral earth pressures which are largest at the base of the island beneath the crest must be carried by the strength of the fabric to ensure that the island will remain intact. The fabric will preclude any mixing of soil 1 with soil 2 and should minimize spreading of soil 2. A second force (squeezing out force) is acting on the bottom side of the fabric caused by soil 2 trying to squeeze out from under the weight of the island material. The result of these forces would require a fabric of 320 lbs/linear inch, but it is felt that a factor of safety of 2 is needed to prevent fabric creep; therefore, the fabric strength chosen should have a tearing strength of 640 lbs/linear inch at not more than 5 percent elongation. If the fabric chosen is a polyester fabric, it will sink and would help facilitate construction in deep water. Companies such as Nicolon, Inc., and Mirafi, Inc., usually have off-the-shelf fabrics that run in the $5 to $6/yard range. If a polypropylene fabric is chosen, it will have to be weighted down because it floats, and a factor of safety of 2.5 is needed to prevent fabric creep. The 800 lbs/linear inch fabric is priced in the $3 to $4/yard range. The polypropylene fabric may be the better choice because the material will have to be moved around with small boats in the shallow water during placement. The clamshell barge should be able to place fill on the fabric to sink it in place.

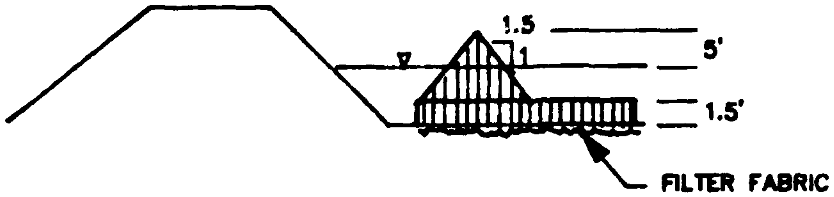
c. Turbidity Curtain.

It is recommended that a turbidity curtain be used to control the silt plume during excavation of the soft lake deposits. It will only be necessary to deploy the curtain around the downstream side of the clam shell operation in the borrow area just excavated, and the curtain will be for the construction phase only. The curtain should extend down to the lake bottom, approximately 3 feet, and should extend a minimum length of 350 feet, as shown in figure G-12.

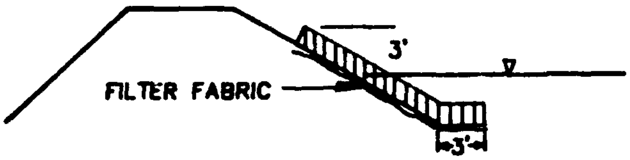
G-5. CONSTRUCTION PROCEDURES.

a. General.

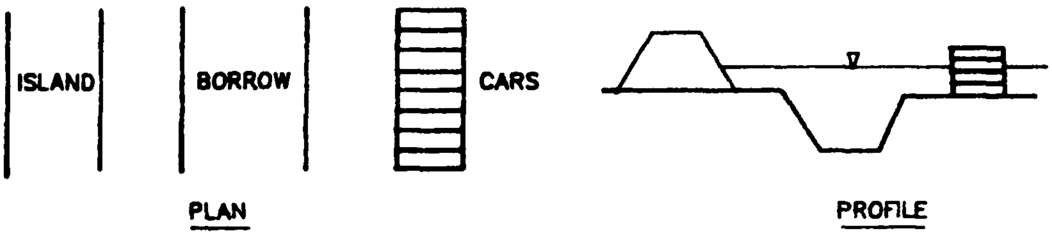
Constructing the barrier island and dredging the channel to open the East River was undertaken as a project to obtain the maximum amount of environmental management for a fixed sum of money. A review of the soil strength



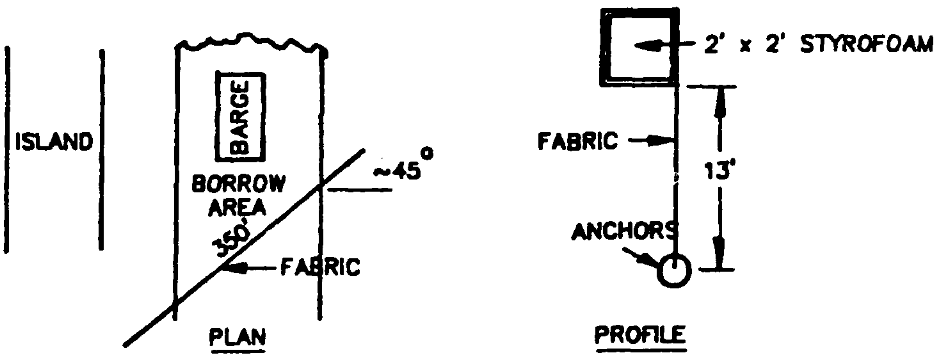
1. FORESHORE PROTECTION



2. BREAKWATER PROTECTION



3. FORESHORE PROTECTION



4. SILT SCREEN

FIGURE G-12. Barrier Island Foreshore Protection and Silt Curtain Alternatives.

data indicated that the island could be constructed by the soil displacement method without the benefit of geotechnical fabric. Soil displacement is a method of foundation or levee construction where volumes of material are simply dumped or placed on soft soils until the weaker soil has been displaced to the depth where the soil beneath the fill becomes stable. In many cases, 4 to 5 volumes of fill below grade are required before 1 volume is stable above grade. Soil displacement is the least costly alternative if the volume of material displaced is not excessive and if the material can be placed to design heights. For the soil displacement method, fill is sidecast to the construction site and spread progressively, beginning from one end of the embankment offering simplistic construction procedures and minimal equipment mobility.

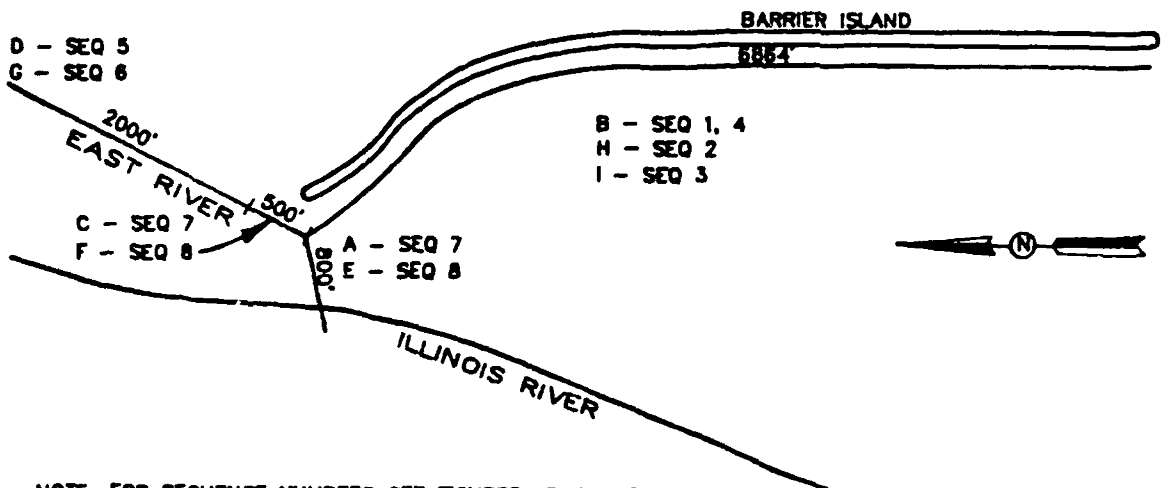
For this site, borrow material was available in the lake bottom along the project alignment, and a barge-mounted clamshell was determined as best suited to move the material. Using the near surface soils along the alignment of the island, it was not considered possible to construct the island to the desired section and grade in one pass. Construction sequences should be timed to allow the maximum time between passes or lifts for the barrier island. Placement of soft material under water is difficult, and the strengths attained during placement will depend not only on the initial strengths but on the arrangement of the individual buckets of material after it leaves the clamshell. The East River embankment might remain stable at a height of 5 to 7 feet in one pass because the soil would be placed on dry land and less mixing would take place with the water, thus, higher strengths as-placed. Construction in lifts or passes would allow time for the placed material to drain and strengthen, while some shrinkage and settlement would occur prior to successive lifts. Wide, low-height placement would result in the maximum increase in desirable soil parameters, but the exact time required between lifts would be affected by the character of the fill material after placement and climatic conditions including water levels at the island. The first lift of material for the island will clear the water surface by a foot or two and will likely require another two lifts to complete the entire 6-foot-high (above water) island. If the material is to be shaped inside the island, temporary stockpiles should be limited to approximately 3 feet in height and shaped as soon as possible.

Calculations in this report were based on the geometry and site conditions as shown. Although soil properties and subsurface conditions were important, the geometry was based on barge equipment with a crane capable of using a 180-foot boom while operating a 7-cubic-yard clamshell. If the geometry is changed, new stability calculations would be needed. Also, the larger bite taken by the 7-cubic-yard clamshell means that there would be less mixing of the borrow material with the water and, therefore, a higher strength in the island would be possible. This size and type of clamshell equipment has been used on similar projects.

b. Summary.

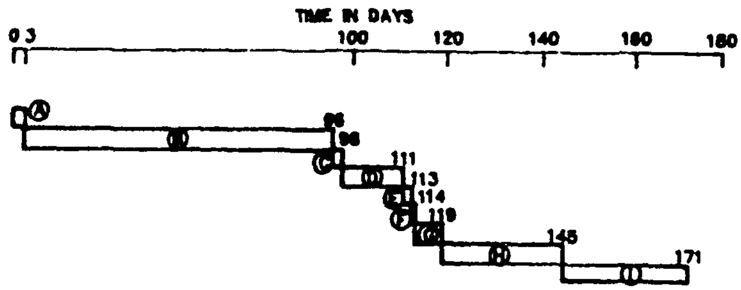
To complete the construction of the island and the dredged material placement areas, it must be stressed that soft soil construction is difficult and that the soil gains needed strength with time as it is allowed to consolidate. The contractor should not be allowed to "throw" the material from the clamshell but must "place" the clamshell and then release the material to retain maximum strength from the in situ borrow material. Operating distances from the barge (or borrow area) to the toe of the island should be strictly maintained to avoid stability failures.

A construction sequence for the island and the placement areas is shown in figures G-13, 14, 15, and 16. The sequence is considered the absolute minimum amount of time in which the project could be completed, and some adjustments may need to be made in the time and volume requirements. The time of 171 days (figure G-13) is based on 24-hour days and an average of 4,000 cubic yards per day of placed material. The actual excavation procedures shown in figures G-14, 15, and 16 are planned to permit as much time as possible between sequential placements, especially for the island construction which is considered to be the most difficult. Time is needed for the soil to gain strength due to consolidation, and this strength is essential because placement of the succeeding layers for the island will be on minimum strength borrow material. The sequence time history shown in figure G-13 is based on continuous construction days, but the success of the project would certainly not suffer from shorter construction days, thus extending the overall construction time periods. It is realized that economics will dictate overall project length, but if time can be allowed, it should be between the first, second, and third passes on the island construction.



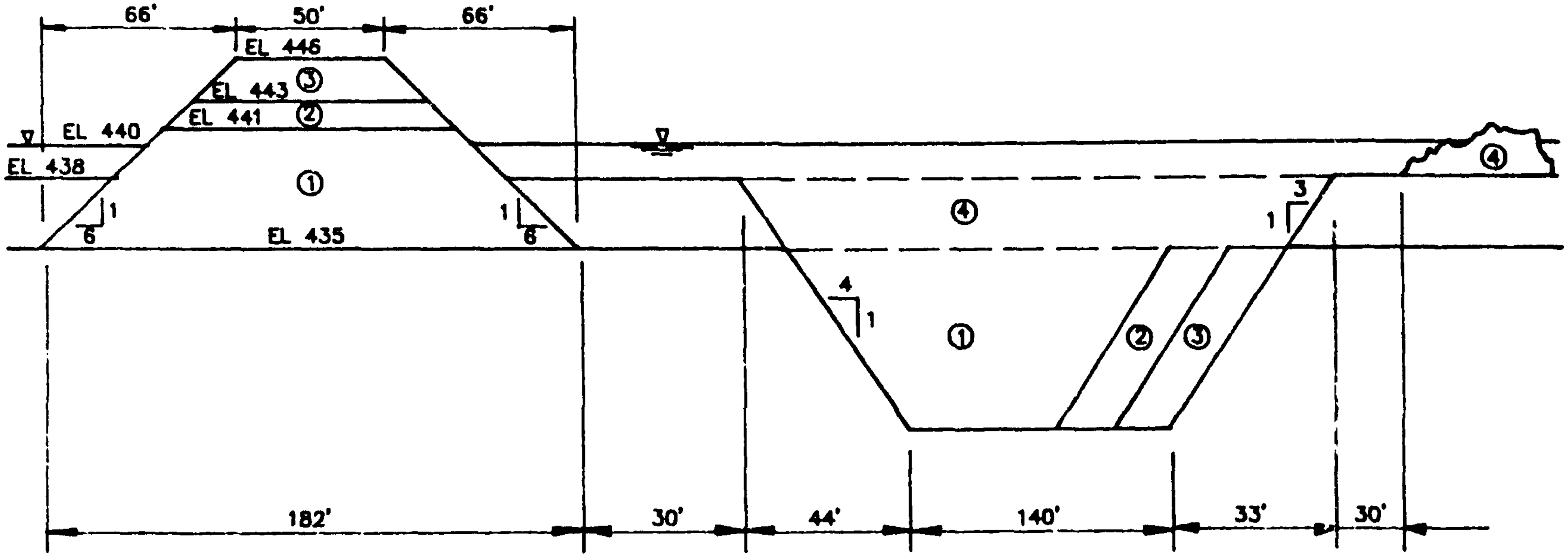
NOTE: FOR SEQUENCE NUMBERS SEE FIGURES 13, 14, 15.

NOTE: For sequence numbers, see Figures G-13, 14, and 15.



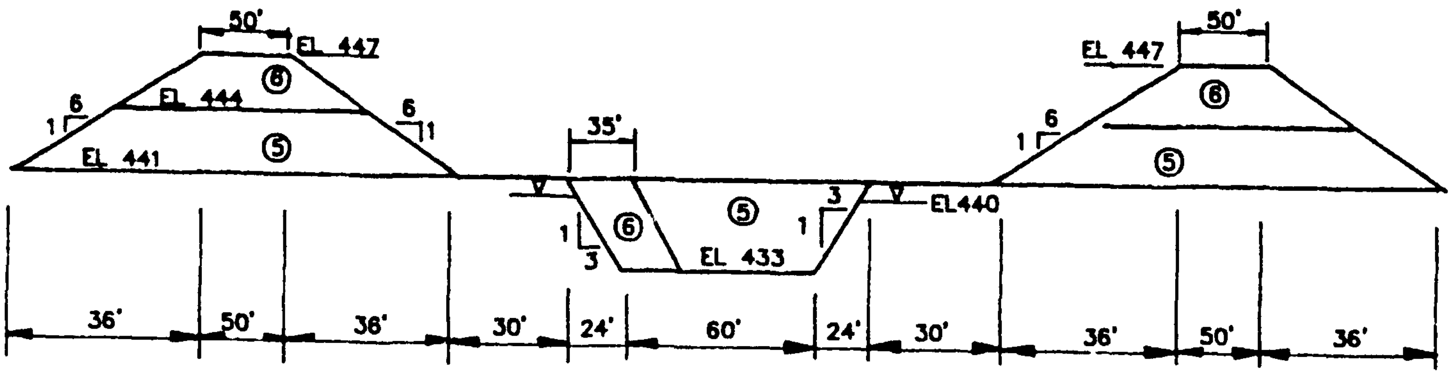
BASED ON 4000 YD^3/DAY AVERAGE
24 HOUR DAY

FIGURE G-13. Proposed Construction History.



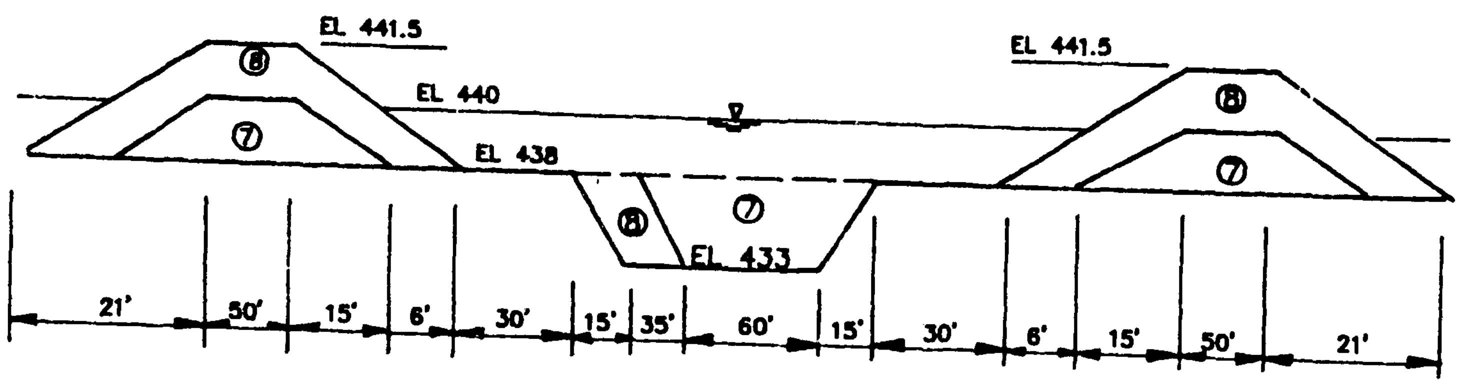
NOTE: NOT TO SCALE

FIGURE G-14. Barrier Island Material Placement Sequence.



NOTE: NOT TO SCALE

FIGURE G-15. East River Material Placement Sequence.



NOTE: NOT TO SCALE

FIGURE G-16. Entrance Channel Material Placement Sequence.

PEORIA LAKE

BEARING CAPACITY, BARRIER ISLAND

2' WATER

γ_w = 93.5 PCF

3' C = 50 PSF SOIL 2

γ_w = 110 PCF

7' C = 320 PSF SOIL 3

SOIL 2

q_{ULT} = 5.14 C
= 5.14 (50)
= 257 PSF

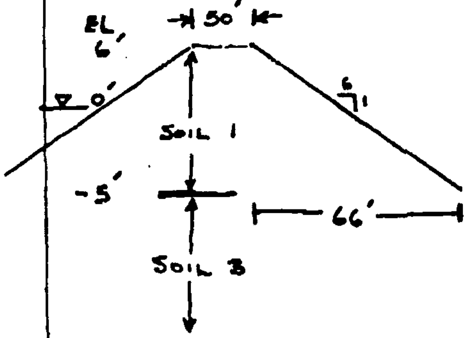
$q_A = \gamma_w h$

257 = 93.5 h

h = 2.7'

FOR SOIL 2 PLACED ON SOIL 2

OVERALL BEARING CAPACITY OF FINAL EMBANKMENT (BARRIER ISLAND)



BEARING CAPACITY

$q_{ULT} = CN_c = 5.14 (320) = \underline{1644 \text{ PSF}}$

APPLIED STRESS

$\sigma_v = \gamma_s H_1 + \gamma_B H_2$

$\sigma_v = 110(6) + 47.6(5) = \underline{898 \text{ PSF}}$

APPLIED BEARING CAPACITY

$$q_a = \frac{2(\sigma_v \times \frac{b}{2}) + \text{CREST WIDTH} \times \sigma_v}{(2 \times \text{DIKE SLOPE WIDTH}) + \text{CREST WIDTH}}$$

$$q_a = \frac{2(898 \times 66/2) + 50 \times 898}{(2 \times 66) + 50}$$

q_a = 572 PSF

FS = q_{ULT} / q_a

FS = 1644/572 = 2.8

FIGURE G-17. Bearing Capacity Computations.

SETTLEMENT - CENTER PT, SOIL 3, BARRIER IS.

6'	$\gamma_w = 110$ PCF	SOIL 1
5'	$\gamma_b = 47.6$ PCF, $e_o = 1.12$, LL = 77	SOIL 1
7'	$\gamma_b = 47.6$ PCF, $e_o = 1.01$, LL = 51	SOIL 3

$C_c = .009(LL-10)$

$= .37$

$\Delta P_1 = 6(110) + 5(47.6)$

$\Delta P_1 = 898$ #/FT²

$P_1 = 2(62.4) + 3(51)$

$+ 3.5(47.6)$

$P_1 = 385$ #/FT²

$$\rho = H_1 \frac{C_c}{1+e_o} \log \frac{P_1 + \Delta P_1}{P_1}$$

$$= \frac{7(12)(.37)}{1+1.01} \log \frac{385+898}{385}$$

$\rho = 8$ IN

$$t = \frac{T_v H_2^2}{C_v}$$

$$= T_v \frac{(7 \times 12 \times 2.54)^2}{1.8 \times 60 \times 60 \times 24}$$

$t = 2927\ T_v$

$t_{50} = 576$ days

SETTLEMENT - CENTER PT, LOWER SOIL 1, EAST RIVER

6'	$\gamma_w = 110$ PCF	SOIL 1
2'	$\gamma_w = 110$ PCF	
5'	$\gamma_b = 47.6$ PCF	SOIL 2
8'	$\gamma_b = 47.6$ PCF, $e_o = 1.05$, LL = 60	SOIL 1

$C_c = (.009)(LL-10)$

$= .45$

$\Delta P_1 = (6+1)110 + 6(47.6)$

$= 1056$ #/FT²

$P_1 = (1)110 + 6(47.6) + 4(47.6)$

$= 586$ #/FT²

$$\rho = H_1 \frac{C_c}{1+e_o} \log \frac{P_1 + \Delta P_1}{P_1}$$

$$= \frac{8(12)(.45)}{1+1.05} \log \frac{586+1056}{586}$$

SETTLEMENT $\rho = 9''$

FIGURE G-18. Settlement Calculations.

GEOTECHNICAL CONSIDERATIONS
FOR
FORESTED WETLAND MANAGEMENT AREA (FWMA)

A

P

P

E

N

D

I

X

H

UPPER MISSISSIPPI RIVER
ENVIRONMENTAL MANAGEMENT PROGRAM
DEFINITE PROJECT REPORT
WITH INTEGRATED ENVIRONMENTAL ASSESSMENT (R-6F)

PEORIA LAKE ENHANCEMENT
PEORIA POOL, ILLINOIS WATERWAY RIVER MILES 178.5 TO 181
STATE OF ILLINOIS

APPENDIX H
GEOTECHNICAL CONSIDERATIONS FOR FORESTED WETLAND MANAGEMENT AREA (FWMA)

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DEFINITE PROJECT REPORT
WITH INTEGRATED ENVIRONMENTAL ASSESSMENT (R-6F)

PEORIA LAKE ENHANCEMENT
PEORIA POOL, ILLINOIS WATERWAY RIVER MILES 178.5 TO 181
STATE OF ILLINOIS

APPENDIX H
GEOTECHNICAL CONSIDERATIONS FOR FORESTED WETLAND MANAGEMENT AREA (FWMA)

H-1. PURPOSE.

This appendix is intended to depict the general geologic setting and conditions of the foundation for the moist soil unit with controlled water levels for wildlife habitat and for developing a green tree reservoir.

H-2. LOCATION.

The Peoria Lake Enhancement project lies within the Bloomington Ridge Plain of the Central Lowlands Physiographic Province. The site is situated in western Tazewell County, Illinois. This project is located along the Illinois River between river miles 178.5 and 181, covering approximately 180 acres.

H-3. PHYSIOGRAPHY.

The Peoria area lies in the drift plain of the Illinoisan stage. Because the valley systems have eroded into this area, the flat upland prairies have been restricted. Bedrock is commonly exposed along the larger valleys, and its topography is seen in much of the present land surface because of the thin drift and high bedrock. The Illinois River Valley is about 1 to 3 miles wide in the vicinity of the site. Farther south of the site, the Illinois River flows through the ancient Mississippi River Valley which is 8 to 10 miles wide.

H-4. PLEISTOCENE AND HOLOCENE DEPOSITS.

Glacial activity stretched into Illinois from Canada in the Pleistocene period. In Tazewell County, most of the surface materials are unconsolidated materials deposited by glacial advances. The majority of these deposits were generated by glacial meltwater and post-glacial streams. Some sands in the area are considered wind-blown deposits. In most of the county, the drift that is present has been termed Wisconsinan, the most recent glacial advance. However, in the west and south-central portions of the county, the drift is Illinoisan.

H-5. BEDROCK.

The Peoria region lies within the northwestern Illinois coal basin. Bedrock was not encountered on any of the borings; however, the bedrock terrain is evident from the irregularities on the plain surface. Below the approximate 500 to 700 feet of Quaternary deposits lie alternating Pennsylvanian sequences of sandstone, shale, underclay, coal, and limestone. This strata consists of the Modesto and Carbondale Formations. These cyclothermic beds lie unconformably on Mississippian age shales and limestones.

H-6. SUBSURFACE EXPLORATIONS.

Access to the project site was limited by the dense brush and trees. During May 1989, seven primary borings, PM-89-1 through PM-89-7, were taken. Boring PM-89-5 was obtained by hand with a 4-inch Iwan auger. Borings PM-89-1, 2, 3, 4, 6, and 7 were obtained with a CME-550 drill rig using a 3-1/4-inch hollow stem auger.

In addition to the Corps of Engineers' borings, the Illinois Department of Conservation provided six soil borings. These borings numbered B1 through B6 and were taken by A & H Engineering Corporation during December 1980.

Samples of all borings were taken at 2-foot depth intervals or at visual changes of material. Tests of soil samples included moisture content, gradation and pocket penetrometer tests (in the field), and Atterberg limits. Undisturbed soil samples also were taken to perform triaxial compression tests and to determine shear strengths. These samples were tested in the Missouri River Division Laboratory, Omaha, Nebraska. Locations of the borings are shown on plate 13 of the main report, and the boring logs are shown on plate 7 of the main report.

H-7. GROUNDWATER.

Water level observations were monitored during the boring operations and are noted on the boring logs shown on plate 7 of the main report. Based on these observations, the ground water levels encountered in the vicinity of the proposed embankment area were found to be fairly consistent from hole to hole. The depth at which water was located ranged from 1 to 9 feet, and elevations ranged from 440 to 444 feet MSL; the exception was boring PM-89-6 which had a ground water depth of 15 feet at elevation 435 feet MSL. The water levels are expected to fluctuate with changes in climatic conditions and river levels.

H-8. EMBANKMENT OF LEVEES.

The proposed project consists of five levees. The levees, shown on plate 13 of the main report, are approximately 5 feet high. The purposes of the levees are to create a moist soil unit with controlled water levels for wildlife habitat and to develop a green tree reservoir. The crown of the levees will be 12 feet wide. The side slopes of all levees will be 1 vertical (V) on 3 horizontal (H), with the exception of the riverward face of cell C levee which will be 1V on 6H. The plans and sections of the levees are shown on plates 13 and 16 of the main report. The levees will be built with semi-compacted impervious material. All will be seeded.

H-9. FOUNDATION FOR EMBANKMENTS.

The entire foundation beneath the proposed levees embankment will be stripped of vegetation and other deleterious materials to a depth of 6 inches. All top roots, lateral roots, and trees within the embankment foundation areas will be removed to a depth of 3 feet below natural ground surface.

An extensive field investigation was made to ascertain foundation conditions of the proposed levees. According to borings which were pertinent to approximately 5-feet-high levee foundation analyses, the foundation material consists of alluvial deposits. Boring logs are shown on plate 7 of the main report. The top stratum has an average thickness of 20 feet and consists of normally consolidated, impervious alluvial deposits classified as SC, CL, CL-CH, and CH according to the Unified Classification System.

In Boring PM-89-4, a 3-foot-thick layer of medium to fine sand with clay balls (SP) was found interbedded between lean clay (CL) and medium clay (CL-CH). A moisture content test was determined on every sample of impervious soil, and Atterberg limits testing was performed on the selected soil samples after thoroughly evaluating each soil sample. The test results are provided in table H-1.

TABLE H-1

Geotechnical Properties of Top Stratum

Soil Description	Moisture Content (Percent)	Liquid Limit (Percent)	Plastic Limit (Percent)
CL	21-34	32-43	15-19
CL-CH	26-40	46-47	17-20
CH	32-69	55-76	21-36
SC	12-21		

The standard penetration test "N" values, recorded during the drilling operations for top stratum, ranged from 2 to 11 blow counts with average "N" values of 5. The shear strength of the top stratum based on pocket penetration tests varies from 250 psf to 2000 psf. The undisturbed soil sample test results show that the shear strength ranges from 500 psf to 800 psf. The tests results are shown on plates H-2 and H-3.

The soils below the impervious substratum are found to be medium to fine sand (SP). Gradation tests performed on selected pervious soil samples revealed that the effective grain size (D_{10}) ranges from 0.10 to 0.17 millimeters. Gradation curves are shown on plates H-6 and H-7. The "N" values obtained for the sand ranged from 11 to 13 with average "N" values of 13. The pervious stratum is underlain by impervious clay stratum. Detailed descriptions of the encountered materials are shown on the boring logs and on plate 7 of the main report. None of these borings were extended to bedrock.

H-10. FOUNDATION FOR OTHER STRUCTURES.

Three water control structures, shown on plate 19 of the main report, will be built as part of this project. They will be located as shown on plate 13 (one in each cell). Borings PM-89-1, PM-89-2, and PM-89-4 (one at each site) were taken to evaluate physical characteristics of subsurface conditions.

The borings revealed the presence of about 20-feet-thick alluvial clay deposits (CL, CL-CH, CH, and SC). Boring PM-89-4 showed a 3-foot-thick layer of medium to fine sand with clay balls (SP) interbedded between sandy lean clay (CL) and medium clay (CL-CH). The 20-foot-thick clay top stratum is underlain by medium to fine sand (SP). Detailed descriptions of soils encountered are shown on boring logs on plate 7 of the main report; the borings do not show very soft or undesirable material. Any unsuitable material which might not have been encountered by this boring will be replaced with appropriate fill. The replacement material will be placed and compacted to obtain a density equal to the adjacent undisturbed foundation. Foundation design details of the proposed structures are given in Appendix M - Structural Considerations.

H-11. SLOPE STABILITY.

The proposed levee near station 127+00 is found to be most critical for slope stability analysis for the end of construction condition. The stability of slopes was analyzed by the Modified Swedish Method for a circular Arc slope Stability Analysis in accordance with EM 1110-2-1902, "Engineering Design Stability of Earth and Rockfill Dams," dated April 1, 1970.

A sudden drawdown and steady seepage conditions were not evaluated since high water levels will be of such short duration that saturation of semi-compacted impervious embankment cannot occur, and the Illinois River low water level will not impose any seepage pressure on the levee.

To estimate the stability of the proposed levee with 1V on 3H side slopes, the Q shear strength of semi-compacted impervious fill is anticipated to be at least 700 pounds per square foot (psf) without frictional angle. The design shear strength (Q) of 250 to 500 psf without frictional angle was estimated by the Rock Island District for impervious top stratum based on established correlations between moisture contents and shear strengths for the similar type soils from other projects, undisturbed soil samples tests, the pocket penetration tests, and standard penetration tests results. However, a conservative shear strength (Q) of 225 psf without frictional angle was selected for impervious foundation to compensate for the possibility of localized zones of material of lesser strength than indicated from the results of field and laboratory tests. These values are shown on plate H-1. Successive trials of various sliding surfaces were analyzed and the critical failure arc having the lowest safety factor was determined. The summary of the slope stability analysis and the solution of the most critical arc appears on plate H-1. The computed minimum safety factor of 2.0 for the end of construction condition exceeds the 1.3 required by EM 1110-2-1913, "Design and Construction of Levees," dated March 31, 1978; therefore, no slope stability problems are expected.

H-12. UNDERSEEPAGE.

The underseepage analyses for the proposed levees is based on a thorough study of thickness and permeability, engineering characteristics of the impervious stratum and the pervious substratum, and the extent of the riverward and landward top strata. The underseepage from the moist soil unit toward the river also was considered since 2 feet of water will be maintained inside of the levees.

Case 2 (EM 1110-2-1913) Impervious Top Stratum from both the riverside and landside was considered to be appropriate since a 20-foot-thick top stratum appears to exist on both sides of the 5-foot-high levee and continues infinitely on the landward side. For such a condition, seepage will not occur through the landside top stratum and from the moist soil unit. Therefore, underseepage and berm analysis were not made, and no problems due to underseepage are expected.

H-13. SETTLEMENT.

The embankment near station 127+00 is found to be most critical with respect to settlement study. At this location, the maximum 6-foot-high levee will impose a maximum load of 0.36 ton per square foot on the 21-foot-thick alluvial clay top stratum foundation.

A settlement analysis conforming to Joseph E. Bowles' Foundation Analysis and Design, 3rd edition (1982) indicates total settlement to be on the order of 1.2 feet, as shown on plate H-5. To account for this settlement as well as any unexpected settlement, a shrinkage allowance of 25 percent of the levee height will be provided in the specifications.

H-14. BORROW MATERIAL.

The borrow material will be removed from the adjacent 3- to 4-feet-deep cuts, as shown on plates 13 and 16 of the main report. A 20-foot-wide berm will be left in place between the toe of the levees and near the edge of ditch cuts to ensure the levees' stability and to facilitate construction.

Based on the information obtained from the boring logs regarding the materials in the area, this material should be suitable for use in levee construction. Due to the relative low heights and flat slopes of the embankments needed for this project, the semi-compacted method of material placement is recommended. It is not necessary to incur the expense of drying the materials to optimum moisture content, although drying the back of the adjacent materials may be required for some reaches of embankment construction.

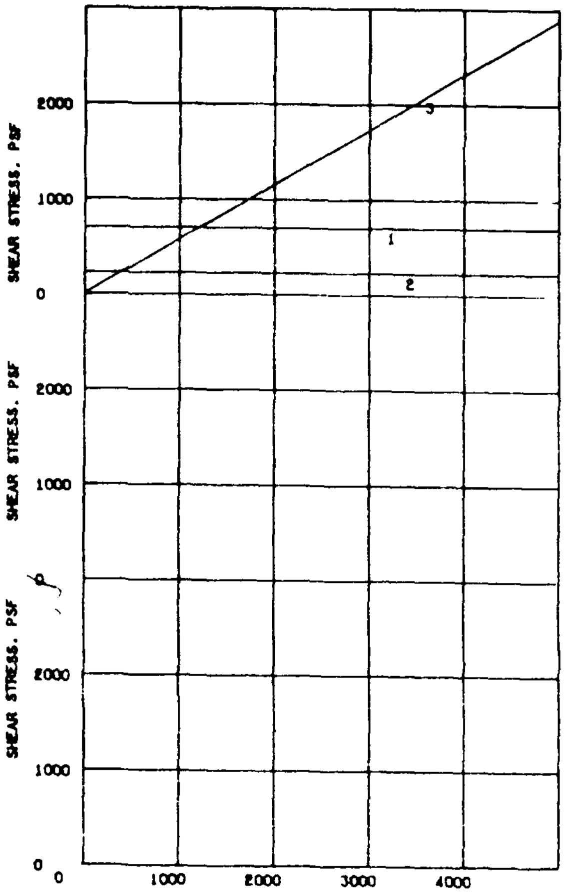
H-15. GROUNDWATER SUPPLY ANALYSIS.

A pump station is proposed to provide water to fill cells A, B, and C. Water levels within these cells would be controlled by stoplog structures. These cells would then be used by migratory waterfowl.

There are two potential sources of water: surface or groundwater. The source must have a capacity of approximately 6,000 gpm and not produce negative effects on other water uses. It was initially desirable to use the goundwater as the water supply source by constructing a new well in cell A. However, the results of a groundwater capacity study indicated that the aquifer could not furnish 6,000 gpm. This conclusion dictated that surface water (from the lake) would be the water supply source. The remainder of this section presents the results of the groundwater capacity study for record purposes.

An analysis of geologic material at the site and the capacity of the aquifer to yield 6,000 gpm of flow was made as shown on plates H-9, H-10, and H-11. The encountered materials previously were described in detail in sections H-9 and H-10. The approximately 12-foot-thick aquifer was found to be confined on top by 15 to 20 feet of alluvial clay. The clay is considered to be impervious. The groundwater level was found to be near the ground surface. Numerous existing pressure relief wells, located in the existing ditch near the proposed pump site, have been flowing continuously. Based on these conditions, the flow for the groundwater analysis was assumed to be artesian. The basic engineering property required for the groundwater supply investigation was the coefficient of permeability (hydraulic conductivity). The permeability of the aquifer consisting of the medium to fine sand was determined from the effective grain size D_{10} (see plate H-8). It is based on effective grain size (D_{10}) using the empirical relationship between D_{10} and K_h (plate H-8) developed from the laboratory and field pumping tests for sand by U.S. Army Corps of Engineers Waterways Experiment Station (WES).

The analysis shows that the aquifer cannot produce the required 6,000 gpm. These results are consistent with the maximum capacity of an existing 8-inch-diameter and 75-foot-deep water well of approximately 800 to 1,200 gpm. This water well is owned by the an adjacent duck club and is located approximately 1,300 feet northeast of the proposed water well. Based on this analysis and existing water well capacity, it was concluded that surface water from the Illinois River or infiltration galleries should be considered.

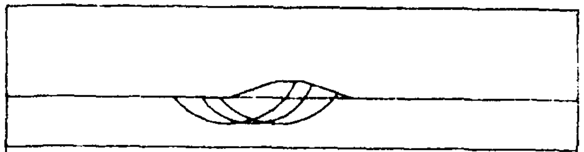


NORMAL STRESS, PSF
DESIGN ENVELOPES

MATERIAL		SOIL WT. LBS./CUFT		SHEAR STRENGTH							
				Q		R		S		(R+S)/2	
		MOIST	SAT.	PHI DEGREES	COHESION PSF	PHI DEGREES	COHESION PSF	PHI DEGREES	COHESION PSF	PHI DEGREES	COHESION PSF
SEMI-COMP. IMP. FILL ELEV 442 TO 449	1	120.00	125.00	0.00	700.00	10.00	300.00	28.00	0.00	19.00	150.00
CLAY FOUNDATION ELEV 421 TO 442	2	115.00	115.00	0.00	225.00	8.00	200.00	28.00	0.00	18.00	100.00
SAND FOUNDATION ELEV 409 TO 421	3	120.00	120.00	30.00	0.00	30.00	0.00	30.00	0.00	30.00	0.00

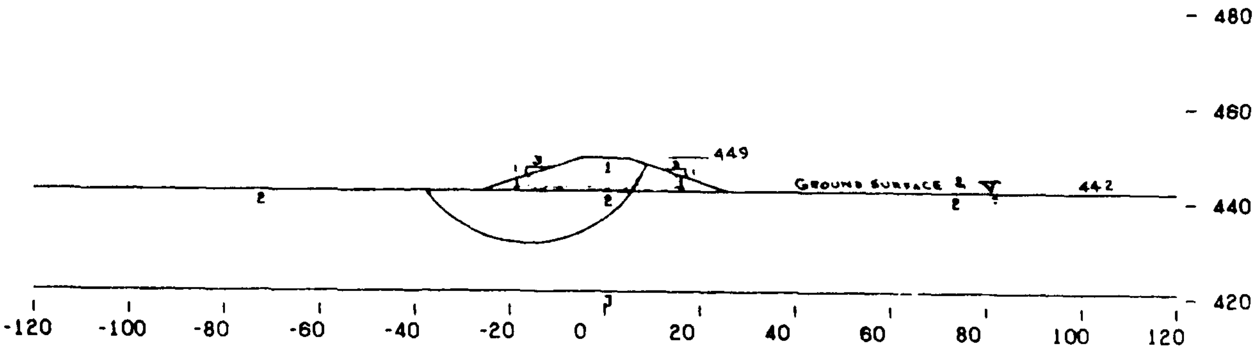
CIRCLE FAILURE SURFACE
RESULTS BY HARRIS-500
COMPUTER PROGRAM 741-H5-F424A
TANGENT TO ELEV 431.00
TRIAL ARCS

RADIUS OF CIRCLE	CENTER OF CIRCLE DISTANCE FROM ℄	CENTER OF CIRCLE ELEV	F.S. Q-SHEAR Ψ= 0.00	F.S. STR.
27.00	-18.00	458.00	2.04	
31.00	-28.00	462.00	2.42	
32.00	-8.00	463.00	4.28	
22.00	-15.00	453.00	2.18	
42.00	-18.00	473.00	2.27	
32.00	-11.00	463.00	2.49	

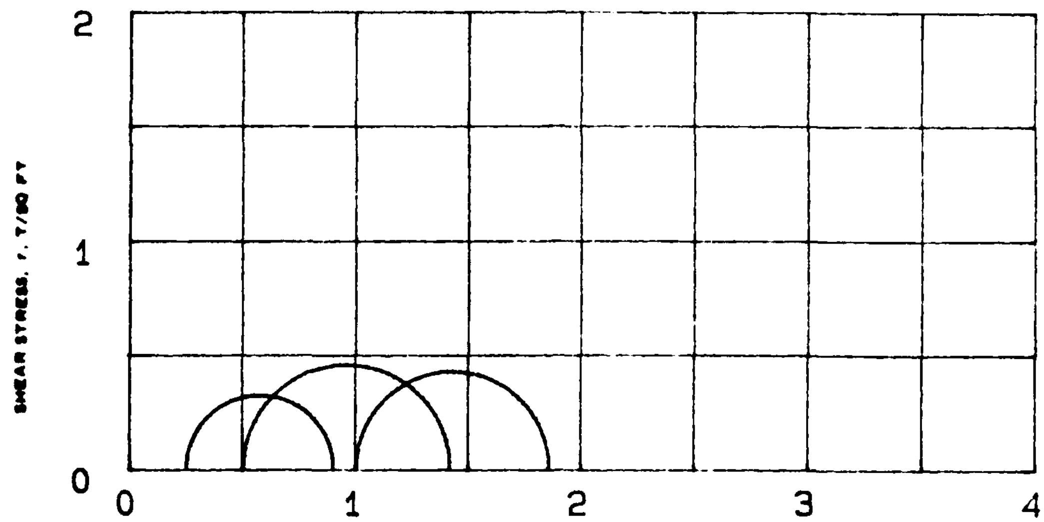


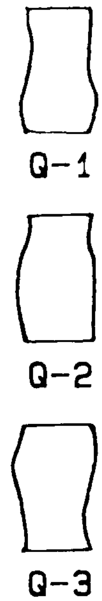
RANGE OF TRIAL FAILURE SURFACES

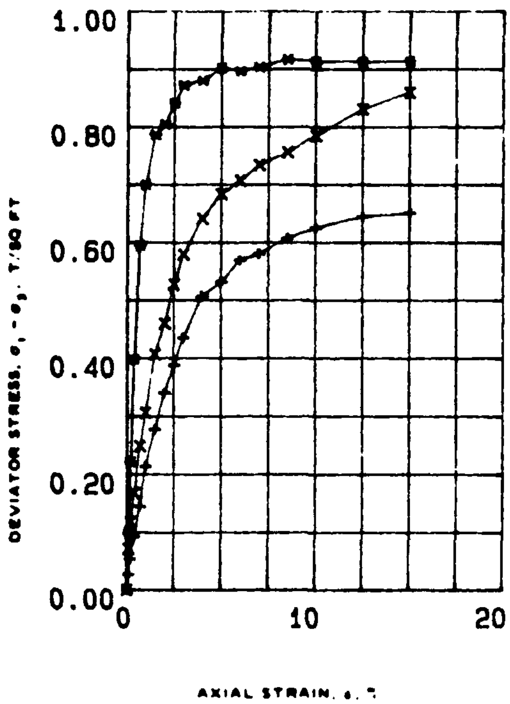
NOTES
1- ANALYSES WERE RUN ACCORDING TO EM 1110-2-1902 DATED APRIL 1970
2- THE SIDE EARTH FORCE DIRECTION WAS TAKEN AS THE AVERAGE OF THE EMBANKMENT SLOPES IMMEDIATELY ADJACENT TO THE SLICE INTERFACE
3- PSI-SIESMIC COEFFICIENT USED IN ANALYSES



PEORIA EMP
SLOPE STABILITY ANALYSIS
END OF CONSTRUCTION
LEVEE A TYP. X-SECTION 127+00
AUG,1980







SPECIMEN NO.			1 (+)	2 (*)	3 (X)	
INITIAL	WATER CONTENT, %	w_o	26.9	22.4	25.1	
	DRY DENSITY LB/CU FT	γd_o	96.6	98.6	94.2	
	SATURATION, %	S_o	99.0	86.0	87.0	
	VOID RATIO	e_o	0.73	0.70	0.78	
BEFORE SHEAR	WATER CONTENT, %	w_c	26.9	22.1	24.8	
	DRY DENSITY LB/CU FT	γd_c	96.6	98.8	94.9	
	SATURATION, %	S_c	98.0	85.0	87.0	
	VOID RATIO	e_c	0.73	0.69	0.76	
	FINAL BACK PRESSURE, T/SQ FT	u_o	0.0	0.0	0.0	
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3	0.3	0.5	1.0	
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{max}$	0.65	0.92	0.86	
TIME TO $(\sigma_1 - \sigma_3)_{max}$, MIN		t_f	31.5	18.8	24.3	
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ult}$	0.65	0.91	0.86	
INITIAL DIAMETER, IN		D_o	1.41	1.41	1.40	
INITIAL HEIGHT, IN		H_o	2.99	2.99	3.00	

CONTROLLED- STRAIN TEST

DESCRIPTION OF SPECIMENS (VIS) Clayey sand, SC

LL 25	PL 14	PI 11	Gs 2.68	TYPE OF SPECIMEN UNDISTURBED	TYPE OF TEST Q

REMARKS Mottled gray-brown.
No torvane. Non-calcareous.

PROJECT PEORIA LAKE; CENCR-ED-6

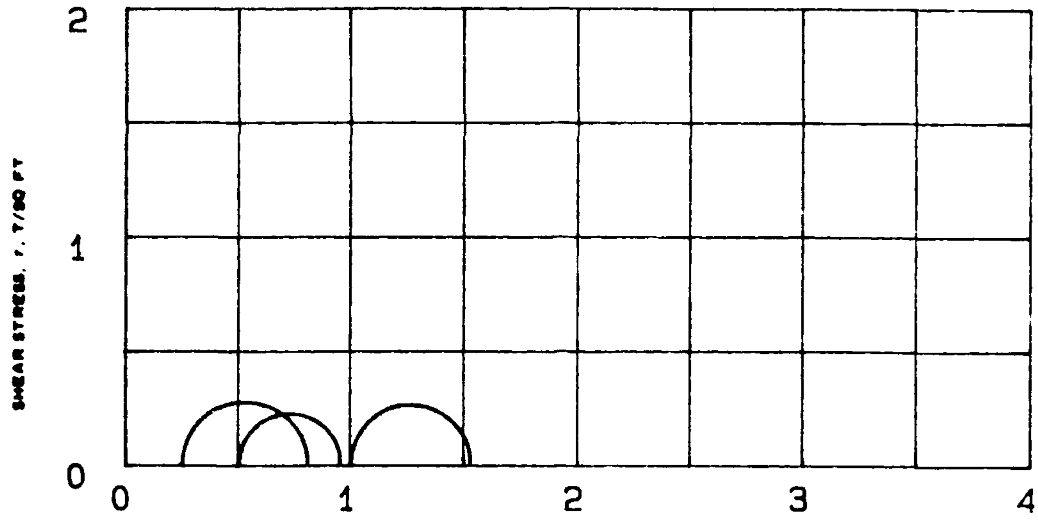
BORING NO. 89-6 SAMPLE NO. 1

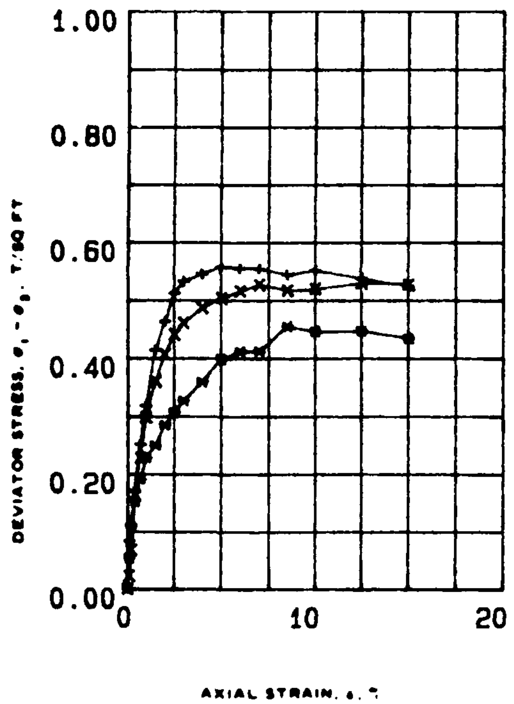
DEPTH/ELEV 4'-6.2'

LABORATORY 89/1293 DATE

TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO. 2089 REV JUNE 1970 PREVIOUS EDITION IS OBSOLETE TRANSLUCENT (EM 1110-2-1906) FIGURE 1





SPECIMEN NO.			1 (+)	2 (✱)	3 (X)	
INITIAL	WATER CONTENT, %	w_o	44.0	45.7	35.8	
	DRY DENSITY LB/CU FT	γ_{d_o}	73.6	75.3	83.8	
	SATURATION, %	S_o	96.0	100.0	100.0	
	VOID RATIO	e_o	1.18	1.13	0.91	
BEFORE SHEAR	WATER CONTENT, %	w_c	43.8	45.5	35.5	
	DRY DENSITY LB/CU FT	γ_{d_c}	73.6	75.4	84.8	
	SATURATION, %	S_c	95.0	100.0	100.0	
	VOID RATIO	e_c	1.18	1.13	0.89	
	FINAL BACK PRESSURE, T/SQ FT	u_o	0.0	0.0	0.0	
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3	0.3	0.5	1.0	
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{max}$	0.56	0.46	0.53	
TIME TO $(\sigma_1 - \sigma_3)_{max}$, MIN		t_f	9.5	14.8	21.8	
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ult}$	0.52	0.43	0.53	
INITIAL DIAMETER, IN		D_o	1.39	1.41	1.41	
INITIAL HEIGHT, IN		H_o	3.00	2.99	3.00	

CONTROLLED- STRAIN TEST

DESCRIPTION OF SPECIMENS Organic, OH

LL 96	PL 38	PI 57	G 2.57	TYPE OF SPECIMEN UNDISTURBED	TYPE OF TEST Q

REMARKS Gray. Too brittle.
No torvane. Non-calcareous.
Slight odor.

PROJECT PEORIA LAKE; CENCR-ED-G

BORING NO 89-6 | SAMPLE NO 2

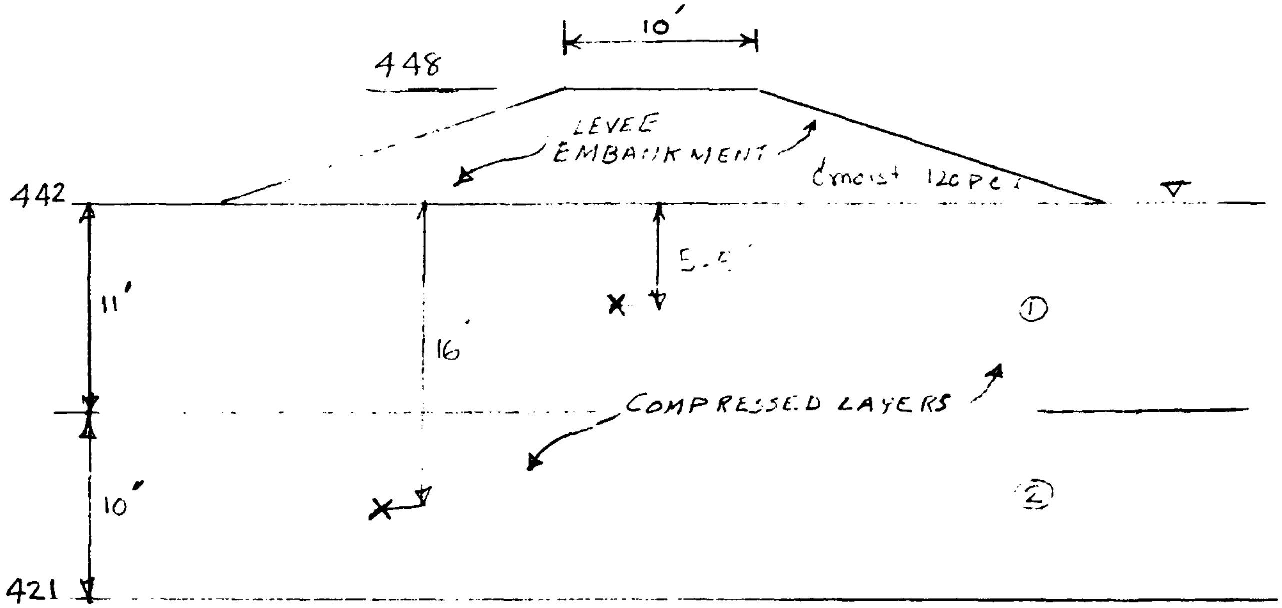
DEPTH ELEV 7.2'-9.1'

LABORATORY 89/1293 | DATE

TRIAXIAL COMPRESSION TEST REPORT

Subject PEORIA EMP		Date
Computed by SZ	Checked by	Sheet of 2

SETTLEMENT ANALYSIS



AVE. MOISTURE CONTENT (W_N) OF COMPRESSED LAYER = 32%
AVE. LL (W_L) = 51%

SPECIFIC GRAVITY (G_S) = 2.7

VOID RATIO $(e_0) = (G_s)(W_n) = (2.7)(.32) = 0.864$

$C_c = .37(e_0 + .003\,W_L + .0004\,W_n - .34)$ REF. FDN. ANALYSIS & DESIGN 3RD EDITION BY JOSEPH E. BOWLES

$C_c = .37(0.864 + .003(51) + .0004(32) - .34) = 0.255$

$C_c = 0.255$ AS RECOMMENDED BY JOSEPH E. BOWELS WHICH HAS A REPORATED 86% RELIABILITY.

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Aug 80

PLATE H-4

Subject PEORIA EMP		Date
Computed by SL	Checked by CJ	Sheet

P_o = INITIAL STRESS

@ MID DEPTH OF LAYER NO. 1 = 5.5 (115 - 62.4) = 289 PSF

@ MID DEPTH OF LAYER NO. 2 = 289 + 10.5 (115 - 62.4) = 841 PSF

ΔP = (BOUSSINESQ COEFFICIENT) (HEIGHT OF LEV...

@ LAYER NO 1 = (0.97) (6) (120) = 698 PSF

@ LAYER NO 2 = (0.75) (6) (120) = 540 PSF

$$\Delta S = \frac{C_c}{1+e_o} H \log_{10} \frac{P_o + \Delta P}{P_o}$$

ΔS_1 FOR LAYER 1 = $\frac{0.255}{1+.864}(11)\log_{10}\frac{289+841}{289} = 0.89'$

ΔS_2 FOR LAYER 2 = $\frac{0.255}{1+.864}(10)\log_{10}\frac{841+540}{841} = 0.29'$

TOTAL SETTLEMENT = **1.2 FEET**

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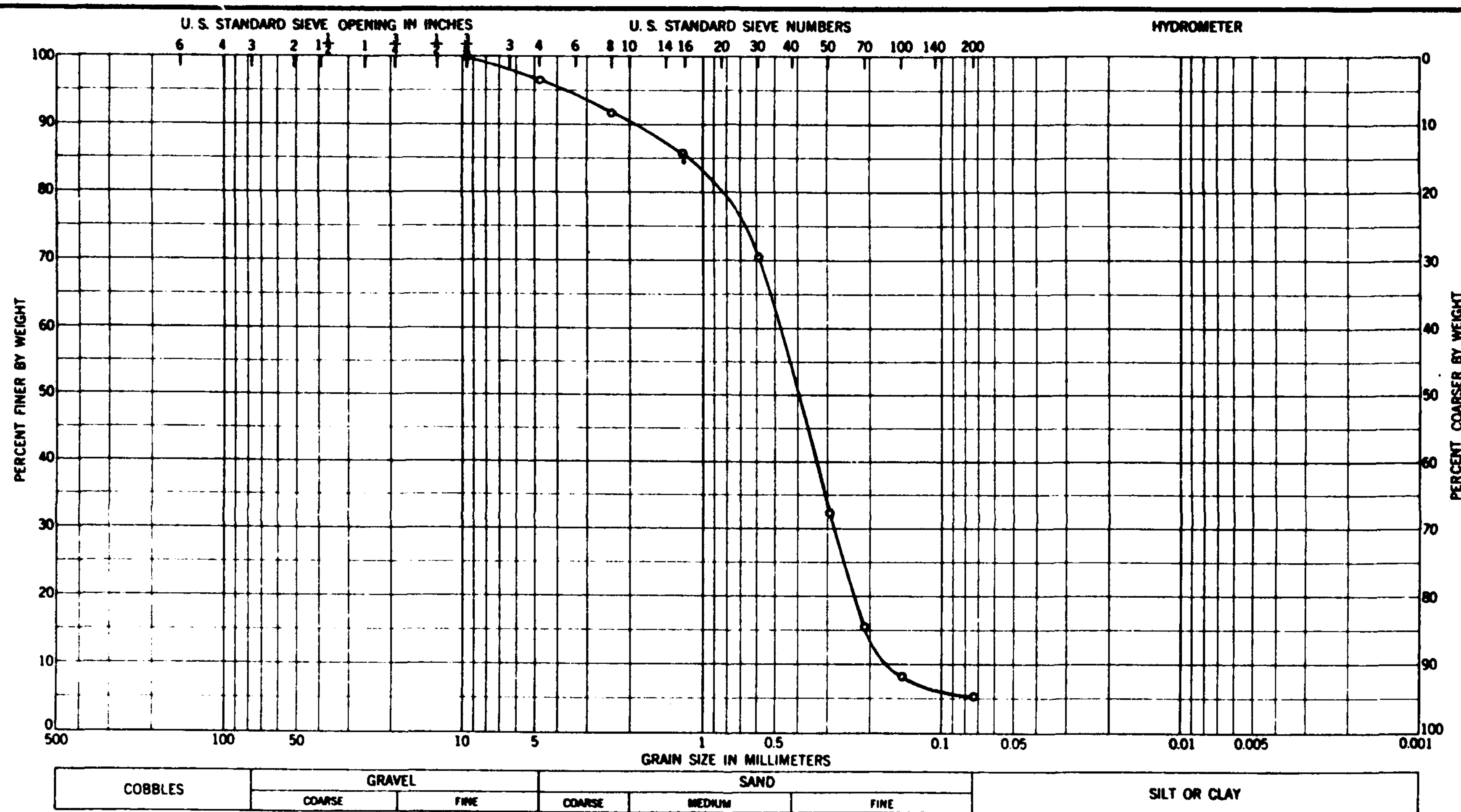


Sample No.	Elev or Depth	Classification			-#200	D10
6	23.5 - 24.5	SP GRAY MEDIUM TO FINE SAND TRACE GRAVEL			5.4%	0.17

Project PEORIA LAKE EMP PROJECT

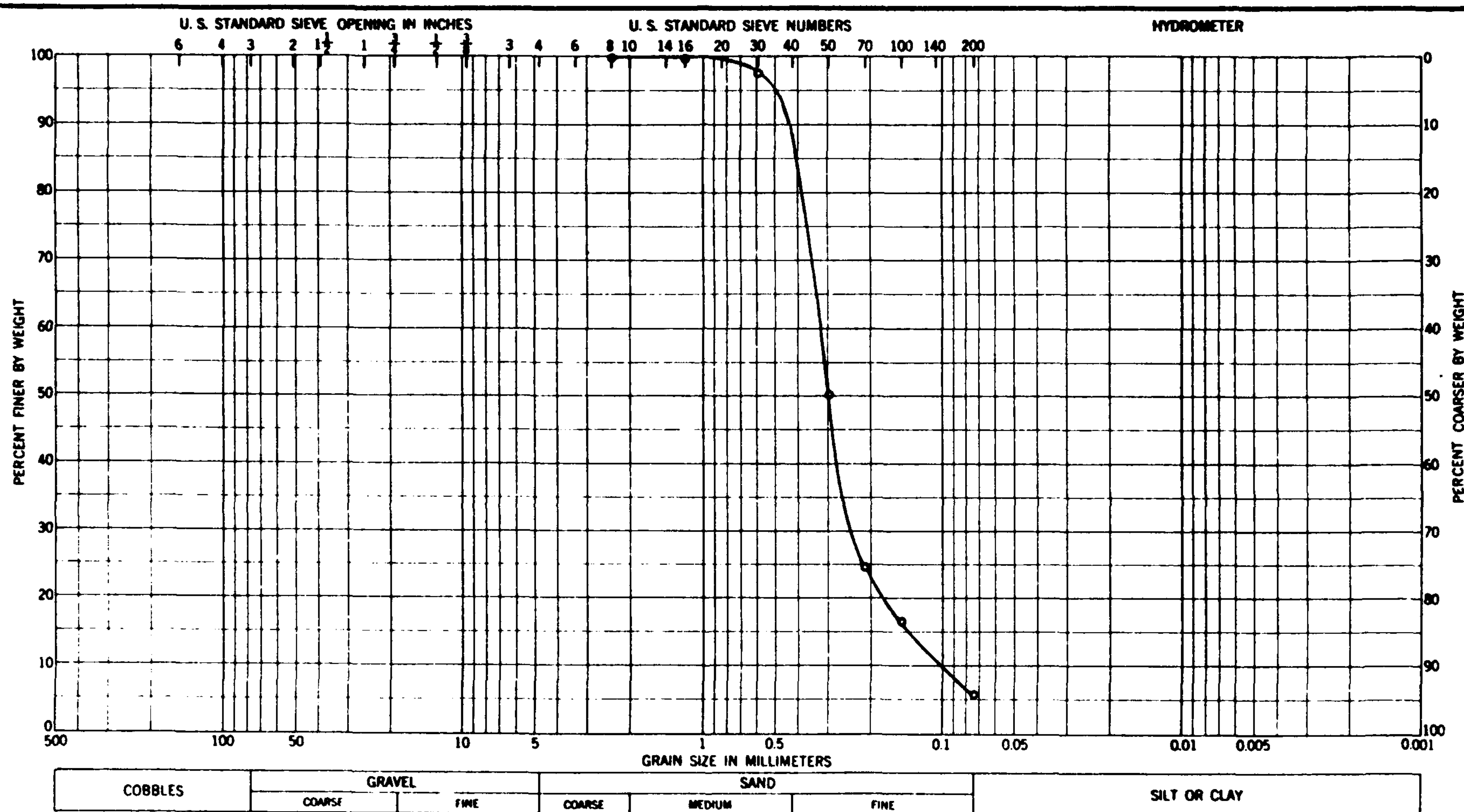
Area MOIST SOIL UNIT

Boring No. PM-89-1

Date 25 MAY 1989

GRADATION CURVES

ENG FORM 1 MAY 63 2087



Sample No.	Elev or Depth	Classification			-#200	D10
8	20.5 - 21.5	SP GRAY MEDIUM TO FINE SAND WITH CLAY SEAMS			6.1%	0.10

Project PEORIA LAKE EMP PROJECT

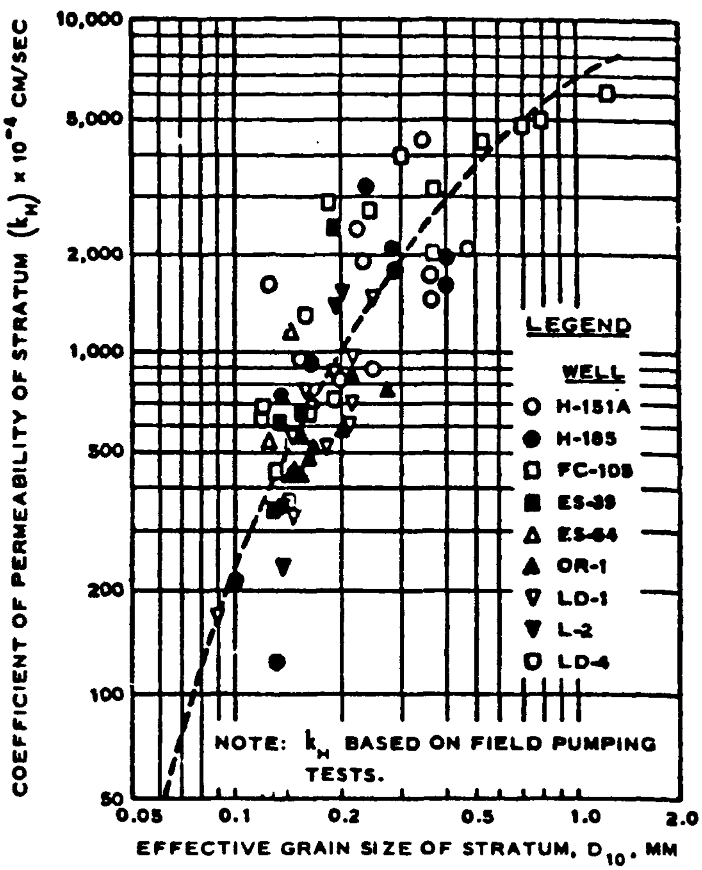
Area MOIST SOIL UNIT

Boring No. PI-89-6

Date 31 MAY 1989

GRADATION CURVES

ENG FORM 1 MAY 63 2087



(b) Effective grain size, D_{10}, versus coefficient of permeability, k_H (from WES TM No. 3-424, ref. A-3b(2)

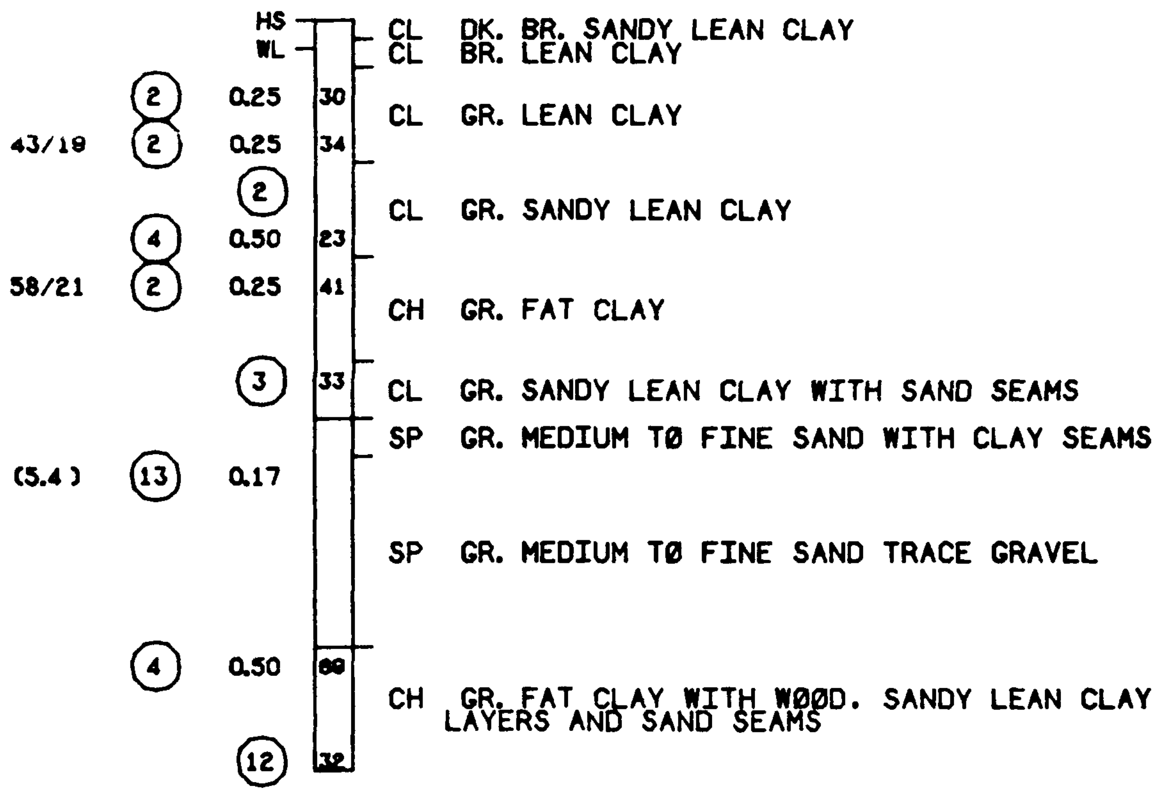
Subject Peoria EMP Project		Date Feb 1990
Computed by SAZ	Checked by ER	Sheet 1 of 3

GROUNDWATER FLOW ANALYSIS

ARTESIAN GROUNDWATER FLOW CONDITION

PM-89-1

TØP ELEVATIØN 442.0



STA 126+90
CENTERLINE
25 MAY 1989

PEØRIA LAKE EMP PRØJECT (MØIST SØIL UNIT)

SCALE: 1IN= 10FT

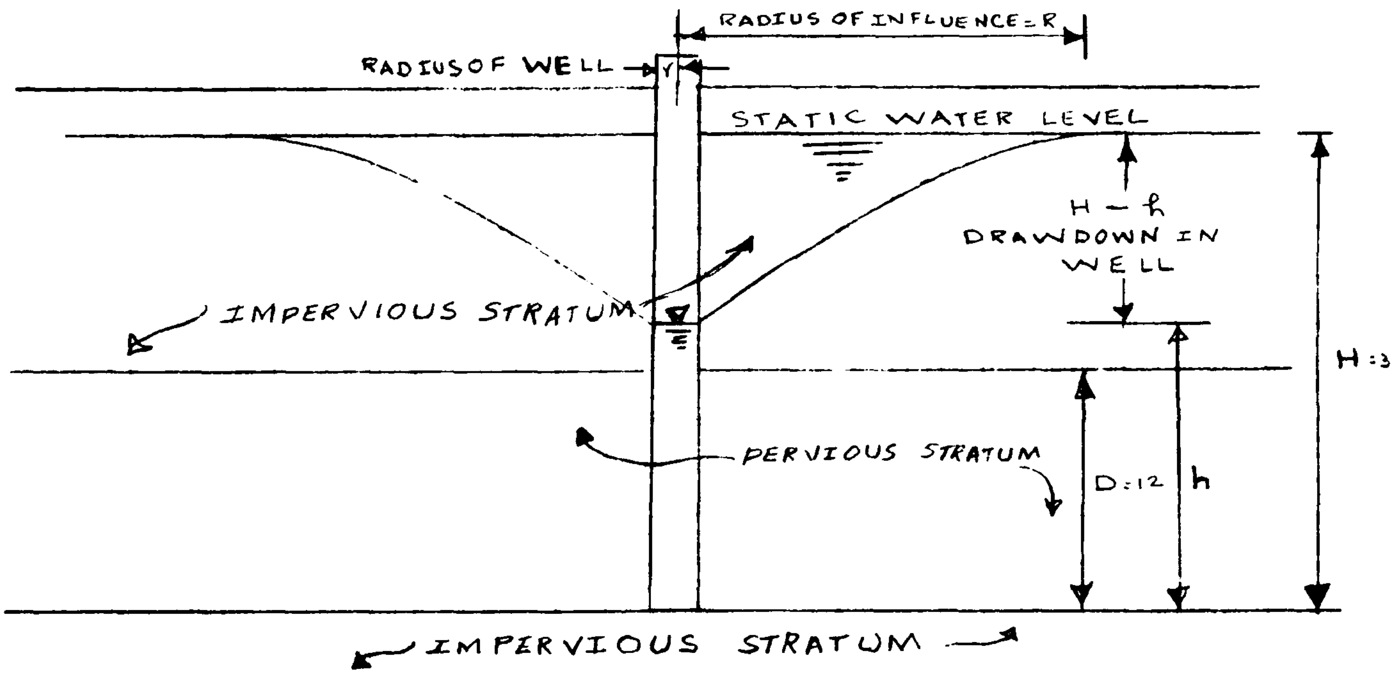
NCR Form 381b
1 Aug 80

PLATE H-9

Subject Peoria EMP		Date Feb 1995
Computed by SAZ	Checked by JR	Sheet 2 of 3

FULLY PENETRATING WELL

CONFINED AQUIFER



$$Q_W = \frac{2\pi K D (H-h)}{\ln (R/r)}$$

WELL IS FULLY PENETRATED INTO THE CONFINED AQUIFER ∴ ALL AQUIFER IS ASSUMED TO BE HORIZONTAL ∴ NO TRANSFORMATION OF THE PERVIOUS LAYER IS REQUIRED.

$D_{10} = .17$ mm

$K_H = 800 \times 10^{-4}$ cm/sec SEE PLATE H-7.

$k_H = .16$ ft/min $= .0027$ ft/sec

D = 12 ft See attached boring on Page 1.

H = 31 ft " " " " "

NCR Form 381b 1 Aug 80

Subject: Peoria EMP Project		Date: Feb 19..
Computed by: SAZ	Checked by: EP	Sheet 3 of 3

$$Q_w = \frac{2\pi K D (H - h)}{\ln (R/r)}$$

REF: TM 5-818-5/AFF 88-5 Chap 6/ NAVFAC P-418. Page 4-25

Check if Q_w = 6,000 GPM can be pumped.

$$6{,}000 \text{ gpm } (2.228 \times 10^{-3}) = 13.4 \text{ cu.ft/sec}$$

$$13.4 \frac{\text{cu ft}}{\text{sec}} = \frac{2(3.14)\left(.0027 \frac{\text{ft}}{\text{sec}}\right)(12 \text{ ft})(H - h)}{\ln (1100/.5)}$$

$$\left(13.4 \frac{\text{cu ft}}{\text{sec}}\right)\left(\ln \left(\frac{1100}{.5}\right)\right) = .2035 \, (H - h)$$

$$H - h = 507 \text{ ft} \quad \therefore \quad H < 380 \text{ ft}$$

THE 12-FOOT THICK AQUIFER IS NOT SUFFICIENT TO SUPPLY 6,000 GPM. THERE FORE, OTHER OPTIONS FOR THE WATER SOURCE ARE RECOMMENDED, SEE PAGE H-6.

<u>EXISTING AQUIFER CAPACITY</u>

$$Q = \frac{2\pi K D (H - h_w)}{\ln R/r} = \frac{2 \times 3.14 \times .16 \frac{\text{ft}}{\text{min}} \; 12 \text{ ft} \; (\text{[illegible]})}{\ln (\text{[illegible]})}$$

([illegible])

$$Q = 223 \text{ GPM}$$

$$Q = 223 \text{ GPM} < Q_{Required} \; (6{,}000 \text{ GPM})$$

NCR Form 381b
Aug 80

WATER QUALITY

APPENDIX I

UPPER MISSISSIPPI RIVER
ENVIRONMENTAL MANAGEMENT PROGRAM
DEFINITE PROJECT REPORT
WITH INTEGRATED ENVIRONMENTAL ASSESSMENT (R-6F)

PEORIA LAKE ENHANCEMENT
PEORIA POOL, ILLINOIS WATERWAY RIVER MILES 178.5 TO 181
STATE OF ILLINOIS

APPENDIX I
WATER QUALITY

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ENVIRONMENTAL MANAGEMENT PROGRAM
DEFINITE PROJECT REPORT
WITH INTEGRATED ENVIRONMENTAL ASSESSMENT (R-6F)

PEORIA LAKE ENHANCEMENT
PEORIA POOL, ILLINOIS WATERWAY, RIVER MILE 178.5 TO 181

APPENDIX I
WATER QUALITY

I-1. INTRODUCTION.

Water quality conditions throughout Peoria Lake are dominated by the shallow nature of the lake and the soft, unconsolidated sediments found throughout the lake. Siltation over the years has severely impaired several beneficial uses of the lake. The majority of the water quality problems observed at Peoria Lake are related to high turbidity values and suspended solids concentrations. These elevated values are a result of agricultural non-point runoff and resuspension of sediments due to wave action from the wind and barge traffic. A secondary impact of the high turbidity values and soft unconsolidated sediments is the virtual absence of rooted aquatic plants throughout the lake. According to Twait, et al., (unpublished report) these types of plants were once present throughout the Illinois River Valley. A major problem encountered in reestablishing aquatic vegetation is uprooting of the plants from the soft sediments by wave action. Twait, et al., (unpublished report) currently are studying the reestablishment of rooted aquatic plants behind a tire breakwater in the lower portion of Peoria Lake. Preliminary data indicate the tire breakwater has been effective in protecting the aquatic plants from uprooting due to wave action.

The majority of water quality information available for the Illinois River is from samples collected from the main channel. The Illinois Environmental Protection Agency rated the Illinois River (255 river miles) as, "partially supporting aquatic life uses with minor impairment." This rating was primarily a result of elevated turbidity values and to a lesser degree, high nutrient concentrations.

Two studies assessing water quality in off-channel areas of Peoria Lake have been performed recently. In conjunction with their aquatic plant reestablishment study, Twait et al. (unpublished report) measured several water quality variables from June 1986 through December 1988 in the lower portion of Peoria Lake. Samples were collected on approximately a weekly basis. Results of this study indicated that comparatively high turbidity values and suspended solids concentrations were common at the study site. Turbidity values greater than 100 NTU and suspended solids concentrations exceeding 100 mg/l were observed on many occasions. In an effort to further assess existing water quality conditions in the vicinity of the proposed Peoria Lake project, a monitoring program was initiated in 1989 by Corps Water Quality and Sedimentation Section (ED-HQ) personnel. The monitoring program called for the collection of water samples on a biweekly basis at two Peoria Lake sites. Low water levels made the sites inaccessible much of the time; therefore, only a limited number of samples were collected.

In order to predict the impact of proposed construction activities on water quality, on December 22, 1988, sediment and water samples were collected. Sediment samples were collected at three sites in the vicinity of the area proposed for dredging for the purpose of performing grain size, bulk sediment and elutriate analyses. Water samples were collected at one site for use in the elutriate test and for ambient water analyses.

I-2. METHODS.

Water and sediment samples were collected by ED-HQ personnel on December 22, 1988. Sediment samples were taken with a 36-inch, plastic-lined, core sampler at sites UPL-1, UPL-2, and UPL-3 as shown on plate 21 of the main report. To obtain a representative sample at each location, at least three subsamples were collected: one near the bow, one amidship, and one near the stern of the sampling boat. Each subsample was placed in a container and mixed to form a homogeneous composite sample. The mixture was then placed into appropriate sample bottles and those to be chemically analyzed were placed on ice.

Water samples were collected with a submersible pump. Water for the elutriate test and ambient water analyses was collected at the surface at site UPL-1 (see plate 21). Each sample was poured into an appropriate container, preserved as necessary, and placed on ice.

Ambient water, elutriate, and bulk sediment samples were shipped on ice to ARDL, Inc., Mt. Vernon, Illinois, for analysis. The elutriate test was used to simulate river conditions that would occur during dredging. The test consisted of combining 50 ml of a wet, well-mixed sediment sample and 200 ml of process water collected from the lake. The mixture was shaken for 30 minutes, allowed to settle for four hours, and the supernatant was drawn off and analyzed. Ambient water and elutriate analyses were performed according to American Public Health Association et al. (1985), or U.S. Environmental Protection Agency (1979). Bulk sediment samples were analyzed according to U.S. Army Corps of Engineers (1981). Duplicate grain size, bulk sediment, and elutriate samples were collected at site UPL-1.

Grain size analyses were performed by Corps Geotechnical Branch personnel according to U.S. Army Corps of Engineers (1986).

On May 24, 1989, a contract which called for the collection of 14 ambient water samples from June through October 1989 at two Peoria Lake sites, was awarded to Donohue & Associates, Schaumburg, Illinois. Water samples were collected just below the surface at sites UPL-A and UPL-B as shown on plate 21 of the main report. Unfortunately, due to low water levels, the sites were inaccessible much of the time. Samples were collected on six occasions at site UPL-A and on four occasions at site UPL-B. Several parameters, including water temperature, Secchi disk depth, water depth, dissolved oxygen, pH, specific conductance, and total alkalinity were determined in the field. Water to be analyzed in the laboratory was poured into appropriate bottles, preserved as necessary, and then placed on ice. These samples were sent to Donohue Analytical in Sheboygan, Wisconsin, for analysis.

Ambient water samples were analyzed according to American Public Health Association et al. (1985) or U.S. Environmental Protection Agency (1979).

I-3. RESULTS AND DISCUSSION.

Grain Size Analyses. Grain size analyses were performed on sediment samples collected at each site on December 22, 1988. The percent sediment passing a No. 230 sieve for each sample is given in Table I-1. The samples collected at UPL-1 and UPL-2 consisted primarily of clay, while the sample from UPL-3 consisted approximately of equal amounts of fine sand and clay.

Bulk Sediment Analyses. Bulk sediment analyses were performed on samples collected at each site on December 22, 1988. The results from these analyses are given in Table I-1. Bulk sediment values were evaluated using a 1977 U.S. EPA publication entitled Guidelines for the Pollutional Classification of Great Lakes Harbor Sediments. These tests were performed as a screening of potentially polluted sediments. Barium, chromium, nickel, zinc, ammonia nitrogen, total volatile solids, cyanide, and manganese exceeded the nonpolluted guidelines. Additional elutriate testing then was performed to further evaluate these sediments. Ammonia nitrogen was the only parameter which exceeded water quality standards as discussed in the following section. The concentrations of several bulk sediment parameters were similar to those observed in Peoria Lake sediments by Demissie and Bhowmik (1986).

Elutriate and Ambient Water Analyses. Elutriate analyses were performed on samples collected at each site on December 22, 1988, while ambient water was analyzed from a sample collected at the surface at UPL-1. Table I-2 contains the results from ambient water analyses and also lists the applicable Illinois General Use Water Quality Standards. The elutriate analysis results, as shown in Table I-3, were also evaluated against these standards. The only elutriate parameter to exceed its standard was ammonia nitrogen. Three of the four samples analyzed had ammonia nitrogen concentrations greater than the state standard of 15 mg/l. The sample from site UPL-3 had an ammonia nitrogen concentration of 14 mg/l. According to Illinois General Use Water Quality Standards, ammonia nitrogen concentrations less than 15 mg/l and greater than or equal to 1.5

mg/l are lawful if the un-ionized ammonia nitrogen concentration does not exceed .04 mg/l. Temperature and pH values are required to determine the un-ionized ammonia nitrogen concentration. Since the pH meter malfunctioned on sampling day, a pH value of 8.0 was assumed when calculating the un-ionized ammonia nitrogen concentration. The concentration determined was greater than .04 mg/l; therefore, it is assumed that the UPL-3 sample also violates the ammonia nitrogen standard.

A parameter for which there is no Illinois General Use Water Quality Standard but which had significantly greater concentrations in the elutriate samples relative to the ambient water sample was total suspended solids. The ambient water concentration was 22 mg/l on the sample date, while the elutriate concentrations ranged from 210 mg/l at UPL-1 to 750 mg/l at UPL-2. However, previous sampling by the Illinois State Water Survey (Twait) yielded values from 28 mg/l to 696 mg/l.

Baseline Water Quality Monitoring. The results from ambient water samples collected at two Peoria Lake sites during 1989 are given in Tables I-4 and I-5. The only parameter to violate Illinois General Use Water Quality Standards was dissolved oxygen. On June 20, 1989, the dissolved oxygen concentration at site UPL-A was 3.70 mg/l, which is below the state standard of 5.0 mg/l. Turbidity values and suspended solids concentrations were relatively high at each site on several occasions.

I-4. CONCLUSIONS.

The results from the analysis of water and sediment samples collected from Peoria Lake on December 22, 1988, indicate that ammonia nitrogen and total suspended solids would be the parameters of concern should dredging occur. Given an initial, minimal mixing zone, ammonia nitrogen concentrations outside of this zone are estimated to be less than the state standard. Total suspended solids concentrations are expected to increase during dredging and disposal operations. The use of a clamshell bucket with gentle placement of material, together with a containment turbidity curtain, would minimize increases in total suspended solids concentrations. Total suspended solids concentrations during dredging and disposal operations would probably be similar to ambient water concentrations observed during high flow periods.

It appears that should the proper dredging and dredged material disposal management techniques be utilized, there will be little impact on the water quality of Peoria Lake. Any impacts that are noted would be temporary in nature.

I-5. REFERENCES.

American Public Health Association, American Water Works Association, and Water Pollution Control Federation. 1985. Standard Methods for the Examination of Water and Wastewater. 16th Edition, APHA, Washington, D.C. 1268 pp.

Demissie, M. and N. G. Bhowmik. 1986. Peoria Lake Sediment Investigation. Illinois State Water Survey, Champaign, Illinois. 88 pp.

Illinois Environmental Protection Agency. 1988. Illinois Water Quality Report, 1986-1987. Illinois Environmental Protection Agency, Springfield, Illinois. 305 pp.

Twait, R., D. Roseboom, A. Kirwin, and T. Hill. 1989. Peoria Lake Restoration (unpublished report). Illinois State Water Survey, Peoria, Illinois.

U.S. Army Corps of Engineers. 1986. EM 1110-2-1906, Laboratory Soils Testing, Appendix V, Grain Size Analysis.

U.S. Army Corps of Engineers. 1981. Procedures for Handling and Chemical Analysis of Sediment and Water Samples. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

U.S. Environmental Protection Agency. 1979. Methods for Chemical Analysis of Water and Wastes. U.S. Environmental Protection Agency, Cincinnati, Ohio.

U.S. Environmental Protection Agency. 1977. Appendix B: Guidelines for the Pollutional Classification of Great Lakes Harbor Sediments. U.S. Environmental Protection Agency, Region V, Chicago, Illinois.

Table I-1. Bulk sediment (mg/kg) and grain size (percent sediment passing a #230 sieve) analysis results from three Peoria Lake sites sampled on December 22, 1988, including a duplicate sample at UPL-1

	LOCATION			
PARAMETER	UPL-1	(Duplicate) UPL-1	UPL-2	UPL-3
Arsenic	2.6	2.8	2.2	2.2
Barium	89	93	81	47
Cadmium	3.2	4.0	3.0	1.4
Chromium	35	34	38	20
Copper	24	23	24	14
Lead	19	19	22	14
Mercury	.26	.37	.23	.32
Nickel	27	28	31	21
Selenium	<.90	<.87	<.76	<.78
Zinc	160	170	160	110
Ammonia Nitrogen	200	52	67	22
Total Volatile Solids	5.8 %	5.2 %	4.7 %	2.6 %
Total Solids	61 %	56 %	65 %	76 %
Oil and Grease	60	650	200	200
Total Organic Carbon	9,000	8,200	9,100	8,600
Cyanide	<.21	.39	<.21	<.21
Iron	15,000	15,000	14,000	10,000
Manganese	340	320	390	350
Aldrin	<.05	<.05	<.05	<.05
Chlordane	<.05	<.05	<.05	<.05
DDD	<.05	<.05	<.05	<.05
DDE	<.05	<.05	<.05	<.05
DDT	<.05	<.05	<.05	<.05
Dieldrin	<.05	<.05	<.05	<.05
Endrin	<.05	<.05	<.05	<.05
Heptachlor	<.05	<.05	<.05	<.05
Heptachlor Epoxide	<.05	<.05	<.05	<.05
Lindane	<.05	<.05	<.05	<.05
Methoxychlor	<.05	<.05	<.05	<.05
Toxaphene	<.05	<.05	<.05	<.05
PCBs	<.05	<.05	<.05	<.05
Grain Size	93.1 %	91.7 %	85.3 %	47.8 %

Table I-2. Illinois General Use Water Quality Standards and ambient water analysis results, in mg/l, from a sample collected at UPL-1 on December 22, 1988

PARAMETER	STATE STANDARD	AMBIENT WATER UPL-1
Arsenic	1.0	<.003
Barium	5.0	.04
Cadmium	.05	<.005
Chromium	-	.03
Copper	.02	<.009
Lead	.1	.10
Mercury	.0005	<.0002
Nickel	1.0	<.025
Selenium	1.0	<.005
Zinc	1.0	<.009
Ammonia Nitrogen	*	.25
Total Volatile Solids	-	21
Total Suspended Solids	-	22
Total Solids	-	540
Oil and Grease	-	8.8
Total Organic Carbon	-	61
Cyanide	.025	.005
Iron	1.0	.97
Manganese	1.0	.04
Aldrin	-	<.05
Chlordane	-	<.05
DDD	-	<.05
DDE	-	<.05
DDT	-	<.05
Dieldrin	-	<.05
Endrin	-	<.05
Heptachlor	-	<.05
Heptachlor Epoxide	-	<.05
Lindane	-	<.05
Methoxychlor	-	<.05
Toxaphene	-	<.5
PCBs	-	<.5
pH (-log[H+])	6.5 - 9.0	**
Temperature (C)	-	1.0

* Ammonia nitrogen shall never exceed 15 mg/l. If ammonia nitrogen is less than 15 mg/l and greater than or equal to 1.5 mg/l, then un-ionized ammonia nitrogen shall not exceed 0.04 mg/l

** Meter malfunction

Table I-3. Elutriate analysis results, in mg/l, from three Peoria Lake sites sampled on December 22, 1988, including a duplicate sample at UPL-1

PARAMETER	LOCATION UPL-1	(Duplicate) UPL-1	UPL-2	UPL-3
Arsenic	<.003	<.003	<.003	<.003
Barium	.12	.11	.13	.13
Cadmium	<.005	<.005	<.005	.01
Chromium	.02	.03	.02	<.009
Copper	.01	.01	<.009	<.009
Lead	.002	<.002	<.002	<.002
Mercury	.0003	<.0002	.0004	<.0002
Nickel	.03	<.025	.03	<.025
Selenium	<.005	<.005	<.005	<.005
Zinc	<.009	<.009	<.009	<.009
Ammonia Nitrogen	16 *	19 *	21 *	14 **
Total Volatile Solids	46	56	130	66
Total Solids	860	710	1,300	790
Oil and Grease	1.6	2.4	5.6	12
Total Organic Carbon	120	91	120	110
Cyanide	<.005	<.005	<.005	<.005
Iron	<.05	.07	<.05	<.05
Manganese	.99	.96	.78	.71
Aldrin	<.05	<.05	<.05	<.05
Chlordane	<.05	<.05	<.05	<.05
DDD	<.05	<.05	<.05	<.05
DDE	<.05	<.05	<.05	<.05
DDT	<.05	<.05	<.05	<.05
Dieldrin	<.05	<.05	<.05	<.05
Endrin	<.05	<.05	<.05	<.05
Heptachlor	<.05	<.05	<.05	<.05
Heptachlor Epoxide	<.05	<.05	<.05	<.05
Lindane	<.05	<.05	<.05	<.05
Methoxychlor	<.05	<.05	<.05	<.05
Toxaphene	<.5	<.5	<.5	<.5
PCBs	<.5	<.5	<.5	<.5

* Exceeds Illinois General Use Water Quality Standard

** Exceeds un-ionized ammonia nitrogen standard if a pH of 8.0 is assumed

Table I-4. Ambient water analysis results from Peoria Lake site UPL-A

PARAMETER	SAMPLING DATE 06/07	06/20	06/27	08/08	08/24	09/19
Depth (ft)	3.5	0.6	0.7	1.3	0.9	5.0
Secchi Disk Depth (ft)	0.8	0.5	0.5	0.8	0.5	1.0
Temperature (C)	25.4	28.5	30.1	28.0	24.9	22.2
pH (-log[H+])	7.91	8.44	7.45	8.78	8.54	**
Specific Conductance (micromhos/cm @ 25 C)	607	774	799	685	695	593
Dissolved Oxygen (mg/l)	7.20	3.70*	10.6	12.85	7.78	7.46
Turbidity (NTU)	61	134	82	65	62	32
Total Alkalinity (mg/l)	139	202	191	167	167	**
Nitrate Nitrogen (mg/l)	8.0	3.78	2.96	2.28	1.56	6.0
Ammonia Nitrogen (mg/l)	<0.04	0.04	<0.04	<0.04	0.11	<0.04
Total Phosphate (mg/l)	0.27	0.54	0.42	0.47	0.41	0.28
Suspended Solids (mg/l)	38	223	104	84	96	24
Chlorophyll a (mg/m3)	11	7	10	<1	3.1	2.2
Chlorophyll b (mg/m3)	123	131	143	3	2.8	<1.0
Chlorophyll c (mg/m3)	154	167	181	5	3.0	2.2
Pheophytin a (mg/m3)	149	175	186	12	2.7	<1.0

* Less than the Illinois Generl Use WWater Qality Standard of 5.0 mg/l for dissolved oxygen

** Meter malfunction

Table I-5. Ambient water analysis results from Peoria Lake site UPL-B

PARAMETER	SAMPLING DATE 06/07	08/08	08/24	09/19
Depth (ft)	3.6	2.2	1.6	5.5
Secchi Disk Depth (ft)	0.7	0.6	0.6	1.1
Temperature (C)	25.5	28.0	21.9	22.4
pH (-log[H+])	7.93	8.92	8.36	*
Specific Conductance (micromhos/cm @ 25 C)	606	675	596	601
Dissolved Oxygen (mg/l)	7.40	14.24	7.71	9.12
Turbidity (NTU)	74	84	94	34
Total Alkalinity (mg/l)	148	171	148	*
Nitrate Nitrogen (mg/l)	8.60	2.10	1.20	6.0
Ammonia Nitrogen (mg/l)	0.04	<0.04	0.16	<0.04
Total Phosphate (mg/l)	0.32	0.59	0.44	0.27
Suspended Solids (mg/l)	52	97	101	24
Chlorophyll a (mg/m3)	10	4	1.9	2.2
Chlorophyll b (mg/m3)	136	3	2.2	1.0
Chlorophyll c (mg/m3)	171	5	3.2	1.2
Pheophytin a (mg/m3)	178	4	4.5	<1.0

* Meter malfunction

The University of Iowa
Iowa City, Iowa 52242

Civil/Environmental Engineering
Environmental Engineering Laboratories
105 Water Plant

319/335-5177

Reference Data to Assess Settling Characteristics (4 pages)

1847

May 05, 1989

Corps of Engineers
Rock Island District
ATTN: CENCR-ED-DG (Holmes)
Clock Tower Building
P.O. Box 2004
Rock Island, Illinois 61204-2004

Dear Mr. Holmes:

Enclosed are the results of the settling column analyses completed in April 1989. Table PL-89-4-1 is the data obtained using the bulk sample #1, from near hole # PL-89-4, Peoria Lake (56.8% dry). Table PL-89-4-2 is the data obtained using the bulk sample #2, from near hole # PL-89-4, Peoria Lake (56.9% dry).

If you have any questions please let me know.

Sincerely,

J. Kent Johnson

J. Kent Johnson, Ph.D.
Laboratory Director

2/4

Table PL-89-4-1

Peoria Lake PL
sample #1
near hole # PL-89-4
depth: none given

TSS(g/L) vs. Time(hrs)
SAMPLE PORTS

	1'	2'	3'	4'	5'	6'	7'
TIME (hrs)	A	B	C	D	E	F	G
0.0	146.2	150.3	141.8	142.6	146.1	1422.8	144.7
0.5	107.7	109.1	115.2	123.1	126.4	133.1	173.2
1	100.7	104.3	105.8	113.3	121.3	131.4	181.6
2	92.2	100.4	102.1	104.2	114.0	121.7	320.5
4	0.5	100.2	100.8	103.2	106.9	113.1	384.9
6	0.1	0.14	98.1	98.9	102.3	132.4	358.4
12	0.07	0.05	0.08	0.1	182.0	252.1	387.6
24	<0.06	<0.06	<0.06	<0.06	44.9	* 259.7	* 421.8
DAY							
2	<0.06	<0.06	<0.06	<0.06	<0.06	* 277.3	* 472.2
3	<0.06	<0.06	<0.06	<0.06	<0.06	* 288.3	* 489.1
4	<0.06	<0.06	<0.06	<0.06	<0.06	* 298.2	* 500.9
5	<0.06	<0.06	<0.06	<0.06	<0.06	* 300.9	* 504.3
10	##	<0.06	<0.06	<0.06	<0.06	59.4	* 548.2
15	##	<0.06	<0.06	<0.06	<0.06	22.5	* 569.8

* Initial filtration indicated a TSS greater than allowed for by the methodology employed. Percent dry weight analyses (dry soil/wet soil sample) were then performed in lieu of total suspended solids.

Water column height below port. No samples could be obtained.

% DRY WEIGHTS
SAMPLE PORTS

TIME (HRS)	F	G
24	22.4	33.5
48	23.7	36.6
72	24.5	37.6
96	25.2	38.3
120	25.4	38.5
240	--	41.0
360	--	42.2

$G_s = 2.60$

Table PL-89-4-2

Peoria Lake PL
sample #2
near hole # PL-89-4
depth: none given

TSS(g/L) vs. TIME(hrs)
SAMPLE PORTS

TIME (hrs)	1' A	2' B	3' C	4' D	5' E	6' F	7' G G/L	w:	lb/cf
0.0	142.8	135.0	140.2	146.8	142.8	148.5	149.2		
0.5	107.7	114.8	116.0	122.8	130.7	137.0	159.5		
1	105.4	108.2	108.7	111.4	122.2	126.4	162.8		
2	17.7	97.8	99.1	103.6	109.6	116.9	298.7		
4	0.09	94.1	97.1	98.0	102.6	107.9	371.7		
6	<0.06	0.1	87.9	91.2	97.8	124.1	351.8		
12	<0.06	<0.06	0.06	0.1	133.0	239.5	385.8		
24	<0.06	<0.06	<0.06	<0.06	29.2	* 259.7	* 418.7	200.3	26.2
DAY									
2	<0.06	<0.06	<0.06	<0.06	<0.06	* 270.5	* 465.6	176.3	29.1
3	<0.06	<0.06	<0.06	<0.06	<0.06	* 277.3	* 484.0	168.1	30.7
4	<0.06	<0.06	<0.06	<0.06	<0.06	* 284.2	* 495.8	167.2	30.9
5	<0.06	<0.06	<0.06	<0.06	<0.06	* 281.5	* 487.3	166.7	30.4
10	##	<0.06	<0.06	<0.06	<0.06	47.5	* 530.4	150.0	33.1
15	##	<0.06	<0.06	<0.06	<0.06	20.3	* 569.8	137.0	35.6

* Initial filtration indicated a TSS greater than allowed for by the methodology employed. Percent dry weight analyses (dry soil/wet soil sample) were then performed in lieu of total suspended solids.

Water column height below port. No samples could be obtained.

% DRY WEIGHT
SAMPLE PORTS

TIME (HRS)	F	G
24	22.4	33.3
48	23.2	36.2
72	23.7	37.3
96	24.2	38.0
120	24.0	37.5
240	--	40.0
360	--	42.2

The following are the calculated percent dry weights that were determined prior to the beginning of the current study.

INITIAL % DRY WEIGHTS	
sample #1	56.8
sample #2	56.9

SEDIMENT HEIGHT (in) vs. WATER COLUMN HEIGHT (in)

	SAMPLE 1		SAMPLE 2	
TIME (hrs)	SED. HT.	WATER HT.	SED. HT.	WATER HT.
0.0	---	91.50	---	89.5
0.5	88.50	91.25	86.50	88.75
1	85.25	90.25	83.50	87.75
2	79.75	89.50	78.50	87.00
4	70.25	88.55	70.25	86.00
6	61.55	87.75	62.00	85.00
12	37.75	86.75	39.00	84.25
24	30.50	85.50	30.50	83.00
48	27.00	84.25	27.00	82.00
72	25.00	83.25	25.00	81.00
96	23.75	81.25	23.75	79.75
120	22.50	80.00	22.25	78.50
240	19.75	77.75	19.25	77.25
360	18.50	76.00	18.25	76.00

NOTE: Approximately 200 mls of sample 2 was spilled when transferring sample into the settling column.

NATURAL RESOURCES DESIGN, MONITORING, AND MANAGEMENT RECOMMENDATIONS FOR THE PEORIA LAKE RESTORATION PROJECT

APPENDIX J

PREPARED BY:
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ENVIRONMENTAL RESOURCES DIVISION
U.S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION
VICKSBURG, MISSISSIPPI

UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
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PEORIA LAKE ENHANCEMENT
PEORIA POOL, ILLINOIS WATERWAY, RIVER MILES 178.5 TO 181
STATE OF ILLINOIS

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STATE OF ILLINOIS

APPENDIX J
NATURAL RESOURCES DESIGN, MONITORING, AND MANAGEMENT RECOMMENDATIONS FOR THE PEORIA LAKE RESTORATION PROJECT

J-1. INTRODUCTION.

a. Background.

Since its construction in 1903, the 14,000-acre Peoria Lake has been the repository of upstream sediment to such an extent that the lake now averages less than 3 feet deep (Demissie, et al., 1988). The lake is silting in at a average rate of 1.5 inches per year, which can be projected to mean that large expanses of Peoria Lake will become emergent wetlands by the year 2010 unless sedimentation rates decline. Sediment cores indicate that bottom material is almost entirely silt and clay of an extremely soft, fluffy nature.

The lake also is subject to a very long wind fetch and considerable wave action. However, Weissinger, et al., (1989) predict that waves will not exceed a maximum height of 1.5 feet under normal wind conditions, with barge tows and boat wakes generating a higher energy force than wind-driven waves. These factors combine to create a situation in which recreational boat traffic is limited, working in shallow water areas is very difficult, and lake waters are generally turbid at all times. High turbidity and wave action, combined with the soft substrate, have effectively reduced the aquatic and emergent vegetation in the lake. All of these factors affect fish and invertebrate populations and wildlife use of Peoria Lake, and have caused a gradual decline in habitat quantity and quality.

The sedimentation occurring in Peoria Lake has affected species composition and distribution. The fish community is dominated by species that can tolerate high turbidity and soft substrates such as gizzard shad (Dorosoma cepedianun) and carp (Cyprinus carpio). Aquatic organisms such as clams and mussels also have been affected due to the softness of the substrate and turbidity.

Water-related wildlife species that now occur in highest abundance are migratory waterfowl using the lake as a brief stopover area. Herons and egrets are commonly observed, but these species are visual feeders and are therefore limited in feeding opportunities except at lake's edge. Gulls (probably immatures or non-breeders) have been observed in relatively large numbers in Peoria Lake during summer months, and migratory seabirds from the Great Lakes and Canada pass through the area as they move up and down the Mississippi River corridor in spring and fall. These are primarily black terns (Chidonias niger), common terns (Sterna hirundo), Forster's terns (Sterna forsterii), Caspian terns (Sterna caspia), herring gulls (Larus argentatus), and ring-billed gulls (Larus delawarensis). Other than for waterfowl, the extent of current use by water-related birds such as belted kingfishers (Megaceryle alcoyon) and by mammals and other wildlife apparently has not been well documented on a year-round basis (Mr. Richard M. Twait, personal communication, Illinois State Water Survey, Peoria, 1989; Mr. Robert Clevenstine, personal communication, Rock Island CENCR District, Rock Island, 1989). Existing baseline environmental data for Peoria Lake were scarce, and collection of these data were not a part of this appendix.

Perhaps more indicative of habitat decline are the changes in shoreline and aquatic vegetation at Peoria Lake. Most islands and shorelines are vegetated with maturing stands of silver maple (Acer saccharinum) and other typical north central U.S. floodplain forest where stable water (pool) levels occur. Almost no emergent herbaceous wetland vegetation occurs outside of protected areas except for infrequent, sparse stands of cattails, bulrushes, and/or arrowheads. Pondweeds, duckweeds, water lilies, and other freshwater aquatics have been nearly eliminated in the turbid water.

b. Objectives.

The U.S. Army Engineer District, Rock Island, has requested that the U.S. Army Engineer Waterways Experiment Station (WES) design habitat improvement features for a portion of Peoria Lake. These features are identified, evaluated, and described in Appendices E, G, and J. The District also has asked for recommendations for implementation, monitoring, and long-range management. Appendix J has been prepared by the Environmental Laboratory, WES. This appendix addresses habitat improvements for fish, invertebrates, and wildlife through island and borrow area habitat design and implementation, including stabilization and vegetation establishment. Habitat improvements discussed in Appendix J include: (a) removal of a silt plug in the East River, resulting in the creation of a three small islands along the river shoreline; (b) the creation of the large barrier island using borrow material from adjacent sediments in Peoria Lake; and (c) and the placement of gravel in rock blankets for aquatic habitat in the river. This appendix discusses applicable techniques and makes recommendations for:

- Problems and opportunities associated with each constructed feature,

- Stabilization and revegetation techniques necessary for developing habitat on all four islands,

- Monitoring techniques and criteria for determining success or failure of the project, and

- Long-range island successional changes.

c. Habitat Development Concepts.

Beneficial use of dredged material is a concept that has long been applied in the CENCR (U.S. Army Corps of Engineers 1986; Landin and Smith 1987; Landin 1988a and 1988b; Landin, et al., 1989a and 1989b). A number of examples of lake restoration using dredging and placement techniques can be applied at Peoria Lake. In addition, a number of applicable habitat development concepts exist. These include bioengineering [1] to stabilize island shorelines and to provide wetland wildlife habitat; placement of gravel bars to develop mussel beds and invertebrate and fish spawning habitat; and design and configurations of deep water borrow pits to attract larger fish. In nearly every lake restoration project, the problem is not how to dredge, but what to do with the dredged material. Pertinent lake restoration projects carried out in the U.S. include 2,881-acre Lake Vancouver, Washington (Gorini 1987) in the Portland Corps of Engineers District and seven smaller lakes in Massachusetts and Connecticut (Walsh, et al., 1988) in the New England Corps of Engineers Division.

The creation of new islands, the structural modification of existing islands, or the habitat development and management of existing islands is also a beneficial use concept that has been used by the Corps for many years (Soots and Landin 1978, U.S. Army Corps of Engineers 1986). The Corps has been building dredged material islands since the turn of the century, with over 2,000 dredged material islands in existence in U.S. waterways. In any given year, approximately one-third of these islands will be used by numerous species of colonial waterbirds and certain waterfowl species for nesting, and virtually all of them receive some wildlife and fisheries use on an annual basis (Landin, et al., 1989a). This use is not limited to avian wildlife; a variety of small mammals, white-tailed deer (Odocoileus virginianus), and wetland invertebrates also are found on dredged material islands. The Corps has developed techniques for revegetating these islands, and for managing existing islands to provide optimum habitat for desired wildlife species (Soots and Landin 1978, U.S. Army Corps of Engineers 1986, Landin 1989, Landin et al., 1989b).

In large U.S. fresh water river systems such as the Mississippi, most wildlife use occurring on both natural and manmade river structures and

1 Bioengineering is defined as engineering in which live plants and plant parts are used as all or part of the building materials for erosion control and landscape restoration, in contrast to conventional engineering where only inert materials are used (Schiechtl 1980).

islands is by waterfowl, interior least terns (Sterna antillarum), other wetlands- and water-related bird species, river otters (Lutra canadensis), muskrats (Ondatra zibethicus), beavers (Myrocastor canadensis), nutria (Myrocastor coypus), raccoons (Procyon lotor), white-tailed deer, coyotes (Canis latrans), and a variety of small rodents and other small animals (Landin 1985). The key to providing habitat by construction of manmade islands is to provide for long-term physical island stability, while allowing for optimum habitat diversity and the life requirements of the desired wildlife species.

Several techniques for the establishment and/or restoration of Peoria Lake's aquatic invertebrates and fish populations have been tested in other lakes and rivers. Placement of barge loads of gravel to provide a different substrate other than silt fluff will encourage the colonization and growth of mussels and certain riverine fishes such as suckers and darters. The construction of a deep water borrow area while building the large barrier island will encourage use by larger fish. The creation of a stillwater area behind the barrier island and the eastern-most small river island will provide for recolonization of aquatic plants. The removal of the silt plug in the East River will cause a stronger current action which will scour softer material and provide a better bottom substrate for aquatic organisms. Aquatic plant growth can be hastened by the introduction of desirable aquatics and by strategic placement of floating structures to further protect and provide for stillwater areas. In turn, these plants will provide food and cover for smaller fish.

Gravel bars are important natural features of rivers and streams that are often altered by lake and water resource development. Gravels and cobbles provide points of attachment and anchorage for immature insects, snails, and worms (Hynes 1970). Coarse-grained particulates also stabilize silt and clay substrate and allow colonization by long-lived invertebrates such as mussels. Particle size distribution, degree of embeddedness, and presence of attached organic matter and plants determine the characteristics of invertebrate communities in lakes (Cummins and Lauff 1969, Brusven and Prather 1974, and Walton 1978).

While gravel bars as rock blankets have been placed in free-flowing rivers such as the Tombigbee and the Ohio to create shoals and bars for aquatic insects, other invertebrates, and fish (Stuart 1953; Shields 1983; Landin and Miller 1988; Miller, et al., 1988a and 1988b), gravel bars in lakes and reservoirs have not been built. However, gravel placement in sufficient quantity and in a carefully chosen location to prevent rapid covering of gravel by silt is operationally feasible. Given the declining quantity and quality of this habitat in Peoria Lake, aquatic habitat should be considered when appropriate materials and sites are available. Where gravel is available for hydraulic removal, creation of rock blankets for invertebrates is relatively inexpensive as part of an ongoing dredging operation, and should be given consideration in early planning and design.

The creation of fisheries features such as borrow pits and protected areas has been carried out in a number of U.S. lakes, including the Great Lakes.

Variation in bottom topography, especially the provision of deeper water areas within a shallow lake or of underwater mounds in a deep lake, is especially important for use by various age classes. Protection by temporary or permanent breakwaters (jetties, wing dikes, floating breakwaters, underwater berms, rubble fishing reefs, etc.) provides stable water conditions that tends to lessen water turbidity and allows aquatic plant growth to occur. This, in turn, provides spawning, nursery, and adult habitat for lake fish.

d. Bioengineering Techniques and Concepts for Stabilization.

Bioengineering concepts are being applied in U.S. lake systems to rectify a number of problems. These problems include long wind fetches, lake turbidity, losses in aquatic and emergent vegetation, declines in water quality, declines in fish and wildlife populations, and shoreline erosion. Europeans, especially West Germany, have been developing and refining bioengineering techniques for decades (Schiechtl 1980, Hoeger 1988). In the U.S., pioneer bioengineering work has been conducted by Hollis H. Allen at WES in Corps reservoirs and on Corps projects on coastal shorelines, and by Robbin Sotir, a private consultant in Georgia, in low-velocity streams. Donald Roseboom of the Illinois State Water Survey has tested willows as shoreline erosion control features at Court Creek, Galesburg, Illinois, in recent years (Mr. Hollis H. Allen, personal communication, WES, 1989).

Twait (1989) has recently been successful in providing fish habitat in a test study in Peoria Lake through the use of a floating tire breakwater coupled with arrowhead (<u>Sagittaria</u> <u>latifolia</u>) plantings inside enclosures. Although plantings are growing well and have survived one winter season, Twait reports problems with waterfowl grazing all vegetation that attempts to colonize outside enclosures, and of tires not remaining afloat. Twait's tests were along a relatively protected shoreline in approximately 18 inches of water (with higher than knee-deep silt fluff). While wave and wind conditions at the barrier island site are expected to be more severe than conditions at Twait's test site, a floating tire breakwater and other temporary breakwaters, or floating islands, are considered feasible concepts at the barrier island.

Specific bioengineering techniques recommended for use in Peoria Lake emphasize stabilization of the four manmade islands. These include revegetation of the islands, a small pilot study using floating vegetated islands as breakwaters and plant propagule sources, biodegradable erosion-control matting coupled with planting of island slopes, and the restoration/establishment of fish and wildlife habitat. Erosion control matting containing living plants, use of woody and herbaceous plant stock, and transplanting and/or seeding the island crest and higher slopes will be discussed in a later section.

J-2. DESIGN AND IMPLEMENTATION.

a. Background.

The WES Geotechnical and Hydraulics Laboratories reports that are included as Appendices E and G to the Peoria Lake Enhancement document give details on engineering and soil/sediment considerations (Leach and Fowler 1989; Weissinger, et al., 1989). By agreement among the three WES laboratories, it is originally recommended that a 1.3-mile-long "S"-shaped barrier island be formed using a barge-mounted dredge, and that the borrow area be on the lakeside of that island. However, one end of the island "S" shape was changed to conform to the location of more stable lake bottom (Figure J-1).[2] The barrier island has been recommended to have no more or less than 1:5 to 1:10 slopes based upon the type of silt material to be dredged. These same slopes are viable from an environmental standpoint. Although a more gentle slope would be easier to stabilize and to revegetate, physical soil properties constrain slope. The barrier island is located near Illinois River Miles 180 and 179 on State of Illinois property (Figure J-1). The barrier island is planned to be 182 feet wide, with a 50-foot-wide crest, and 66-foot 1:6 sloped sides. The island will be 11 feet above existing bottom substrates (approximately 6 feet above mean pool level) (Figure J-2). These feature details are discussed in Appendices E and G.

Since WES was asked to address this project, District plans have expanded to include stabilization and revegetation of three small islands along the East River shoreline and channel to a point where it connects with the Illinois River. Slopes and dimensions of the small islands are given in Figures J-4 and J-6. The small islands will have 1:6 slopes with 50-foot island crests. The easternmost island (left bank, descending) and the up-river portion of the westernmost island (right bank, descending) has a final projected elevation of 6 feet above mean pool level. However, the small island on the left bank, descending, in the outlet channel and the down-river portion of the island (right bank, descending) have projected elevations of only 2.0 feet above mean pool level. This will cause a considerable difference in physical stability and in the vegetation that will survive on the island, compared to the higher islands.

b. The Barrier Island in Peoria Lake.

There are several important environmental reasons for the positioning of the large barrier island and its borrow pit as recommended. The island must withstand erosion forces from wind fetch and wave action within the shallow lake. Curving the island to break some of the wind will aid in its stability. Positioning the borrow area on the lake side will create a deeper area just offshore from the island. This will partially function as

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2 Some figures in Appendix J have been modified from figures used in Appendix G.

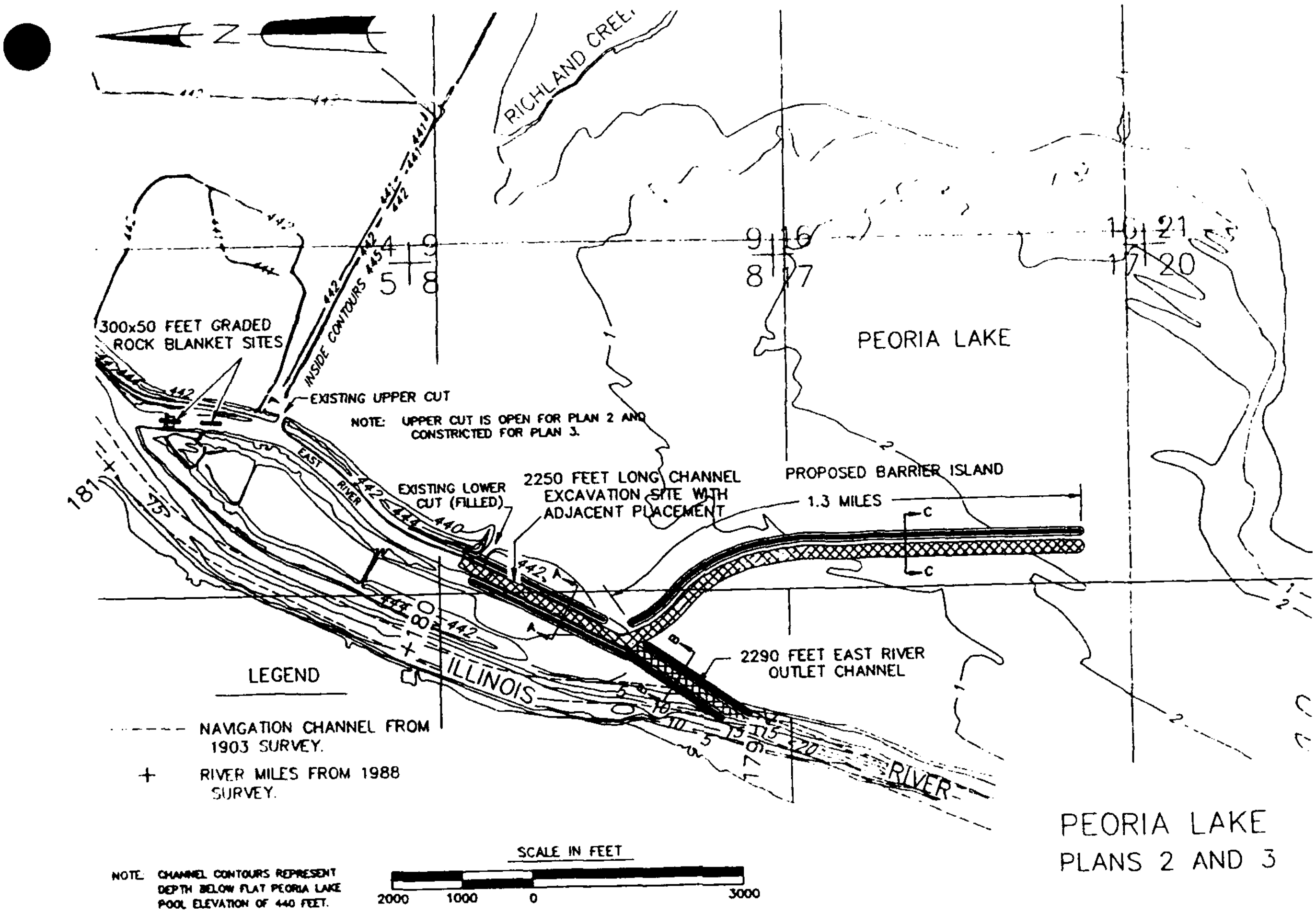
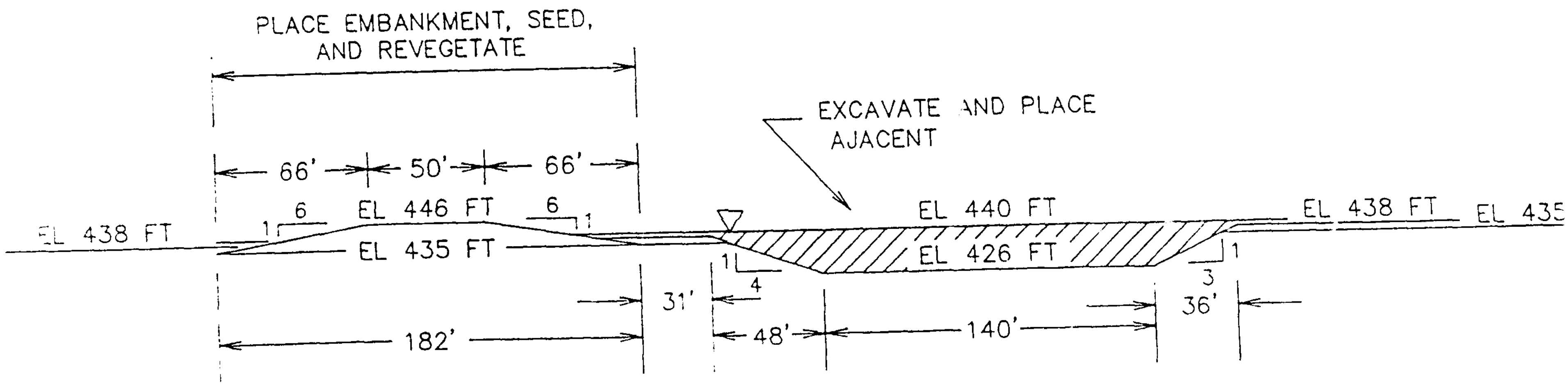


Figure J-1. A schematic showing the location and configuration of the barrier island, three small islands, borrow areas, and the two rock blankets in relation to the Illinois River channel mile markers.



SECTION C—C
BARRIER ISLAND CONSTRUCTION

Figure J-2. A cross-section of the barrier island and its borrow area in relation to normal pool elevation. Note that three feet of the 11-ft height of the island will be taken up in settlement into the soft substrate, and that the island is projected to be six feet above mean pool elevation.

a breakwater. Protection for a large stillwater area in Peoria Lake in the area known as Goose Lake (Figure J-1) by the construction of the barrier island will encourage less turbidity and the development of emergent marsh.

There are also important environmental reasons for barrier island and borrow area slopes. With 1:6 slopes, the island should be able to (a) vegetate rapidly, (b) resist erosion and provide stability, (c) and provide haulout areas for wildlife. Slopes on the borrow area will provide topographic relief and a year-round area for larger fish. The "away" side of the borrow area can serve to further stabilize the barrier island by placement of floating vegetated structures that also will break wave action.

The primary emergent marsh vegetation growing in Peoria Lake consists of arrowheads (Sagittaria spp.), cattails (Typha latifolia, and other less dominant species. Most aquatic plants have disappeared from the lake, but would have been expected to consist of several species of pondweeds (Potomogeton spp. and others), duckweeds (Lemna spp.), water lilies (Nymphaea spp.), and other freshwater aquatics commonly found in midwestern lakes and backwater areas in rivers. The reestablishment of these types of vegetation is important for the improvement of fisheries and water quality in Peoria Lake. In addition, the State of Illinois has been managing small stands of prairie cordgrass (Spartina pectinata). This species is water and alkaline tolerant, and is a good soil stabilizer native to the Midwest and western U.S. It has potential for further introduction and has been suggested for testing at Peoria Lake (Mr. Joseph Slater, personal communication, Rock Island CENCR District, Rock Island, 1989).

The barrier island will be constructed in stages over several months to aid in soil stability and physical formation of the 6-foot-high island above pool level (Figure J-2). After construction of the island is complete and the substrate has had sufficient time to dewater, if necessary, the slopes should be graded to make slope corrections and to provide a suitable substrate for planting. However, note that getting equipment onto the island for site preparation may not be possible due to the silt-clay island material, and that all work may have to be by hand labor and by top-dressing applications of seeds and soil amendments. The outer island slope may be the most difficult to stabilize, since it will face the full brunt of the wind fetch.

As soon as possible after island completion, the entire island should be top-seeded with a mixture (equal percentages of viable seeds by species) of reed canarygrass (Phalaris arundinacea), tall fescue (Festuca elatior), prairie cordgrass (on lower slopes), and winter wheat (Triticum aestivum) to provide a temporary vegetation cover regardless of the time of year that engineering work is completed. (This should occur even if the substrate is still too wet for equipment use -- a hand-held seeder can be used). Reed canarygrass and tall fescue will grow in spring/summer/fall, winter wheat or other winter cover crop will grow during colder months, and prairie cordgrass will grow in summer months at mid to lower slopes on the barrier island. Some plants of these species may propagate and survive for several years, especially the reed canarygrass, tall fescue, and prairie cordgrass.

No nutrient or pH analyses have been conducted for the bottom sediments being used to form the barrier island or other islands. Bottom sediments of silt and clay tend to be acidic (3.0 to 5.5 pH) and may require additions of lime to provide a more neutral pH more suitable for optimum plant growth (6.0 to 7.5 pH range). Since Peoria Lake sediments are primarily derived from farm runoff and include non-point source loads of fertilizers and chemicals typically applied to agricultural crops, bottom sediments already may have adequate nutrient levels for plant growth. Therefore, it is recommended that some basic soil tests be conducted through the Illinois soil testing laboratories or other means to determine if pH, and at least nitrogen, phosphorus, and potassium nutrients, are suitable for plant growth. These analyses will determine the need for lime and/or fertilizer applications on all of the islands; any soil amendment applications should be based on these analyses and rate of application recommendations of the local USDA Soil Conservation Service or USDA county extension agent who are both familiar with soils and soil amendment needs in the Peoria area. A note of caution in dealing with islands is appropriate, in that rate of applications should be kept conservative due to the strong potential for direct runoff into lake waters.

While this temporary cover is growing, the outer face of the slope extending down into the water at least 4 feet (to elevation 439) should be covered with well-anchored, 2-inch-thick biodegradable erosion control matting (Figure J-3). The matting should extend at least 8 feet up the slope above normal pool level (elevation 441.5). The total matting cover will be approximately 12 feet wide and extend around the outer tip of the island, along the shoreline of the outer slope, to a point where some protection from the wind is afforded. The primary purpose of using erosion control matting is to prevent wave and precipitation erosion; there will be no need for use of such matting on the inner slope of the barrier island since it will be protected from wave action by the island itself. The matting used at other shoreline sites for erosion control by WES is constructed of horsehair, coconut fibers, and wood fibers, and costs (1988 dollars) approximately $0.50/square foot in 6- by 50-foot rolls (or $6.00/linear foot or approximately $41,184 for the entire island shoreline). Mat rolls are glued together with water-durable glue and firmly anchored with wood strips and long screw anchors. <u>It should be noted that matting MUST be well anchored to prevent damage from storms or ice until vegetation has established</u>. Such matting also serves as mulch, protection for newly planted seedlings or cuttings and as a substrate for unrooted cuttings. Prices <u>do not include</u> transport of materials, anchors, labor, gluing rolls of mats together, anchoring mats into the island soil, nor planting, which will at a minimum double the price, and is dependent upon local labor rates and the physical and logistical difficulty of working on the site. WES can provide names of suppliers of erosion control matting at the District's request.

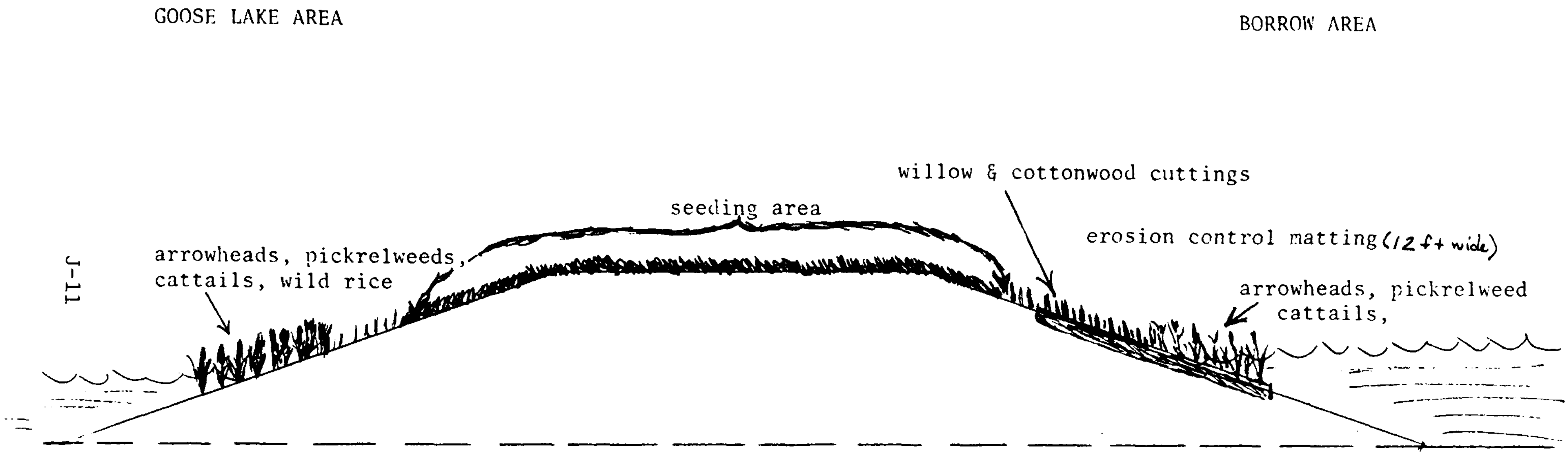


Figure J-3. A schematic cross-section of the barrier island, showing planting zones, and placement zone for the erosion control matting.

Using shears or machete, slits of not more than 6 inches in length on approximately 18-inch centers should be made after the erosion matting is in place and well anchored. Within the slits, at lowest elevations (in standing water), individual arrowhead plants should be sprigged on 18-inch centers to just above normal pool level. This will provide an approximate 4.5-foot-wide planting zone, resulting in the need for an estimated 13,800 arrowhead plants.

Above normal pool level (above elevation 440 feet), cottonwood and willow cuttings should be inserted into the small slits in the remaining matting (7.5 feet) on the outer slope face on 18-inch centers, with the last two rows of cuttings inserted into the substrate up-slope of the matting edge. Cuttings may readily be obtained from donor stands of eastern cottonwood (Populus deltoides), black willow (Salix nigra), sandbar willow (Salix interior). Dormant, live branches approximately 0.5 to 1.5 inches in diameter should be cut in winter or early spring into 15- to 18-inch lengths. These unrooted, unleafed cuttings then should be inserted into the ground up to half of their lengths, in this case through the slits made in the biodegradable matting. If cuttings cannot be planted right away, they need to be heeled into a moist sandy area (and kept moist) until planted to ensure that healthy, live cuttings will be used. Approximately 22,900 cuttings will be needed of the combined species. Equal mixtures of these species are not necessary; they were recommended to provide the best chance of rapid woody ground cover and root development. Actual percentage of cuttings from the mix of species will be determined by the availability of donor trees in the Peoria Lake area. Under natural succession, these typical early colonizing species will be intermixed or displaced by silver maple and other mid- and late-succession floodplain woody species.

The type of planting on the island is at the discretion of Rock Island District. However, woody vegetation is recommended for several reasons: (a) root systems of trees are better stabilizers of silt/clay soils in freshwater systems, and (b) floodplain forest will be the eventual climax vegetation of the island. That ecological process can be hastened by planting of early colonizer tree species. Should the District choose not to plant woody vegetation, the slopes of the islands to elevation 441 could be planted with individual cattail or pickerelweed (Pontederia cordata) or clumps. The use of herbaceous vegetation on the island also has advantages: (a) it will provide more immediate and more diverse invertebrate and wetland-related wildlife cover, and (b) may grow more rapidly. One major disadvantage to herbaceous plantings in Peoria Lake is the very real potential for such plantings to be eaten by wildlife, as Twait's tests have shown (Twait 1989). Another disadvantage is that such herbaceous stands may wash out under storm conditions before they can become well rooted.

Above the cutting placement zone (above the erosion-control matting), the upper slopes and crest should be seeded with a more diverse mixture of herbaceous plants than recommended for the temporary cover. Good choices to include in such a mixture are white Dutch clover (Trifolium repens), timothy (Phloem prates), and other legumes that tolerate upland but moist soil conditions. However, legumes should be included only if pH is higher than 5.5 because these species will not survive in acidic soils. These should be included with prairie cordgrass, tall fescue, reed canarygrass, and other moist-soil grasses. This grass/legume upland mixture will serve as intermediate cover while natural colonization by forbs and seedlings of locally-occurring trees, shrubs, and vines takes place, and will be displaced over time. Locally-recommended seeding rates for the Peoria area should be available at the local USDA Soil Conservation Service office or from the USDA county extension agent; if this information is not available, a custom seeding mixture and soil amendments will be recommended by WES prior to planting and after basic soil analyses are conducted.

On the inner or less-exposed barrier island slope, similar plantings should be made. However, due to less danger of damage to this slope from wind-driven waves, there is no need for matting. Sprigging of arrowhead, pickerelweed, and cattail plants at 18-inch intervals from 4 feet out into the water of Goose Lake area up the slope to approximately elevation 441.5 will provide for the reintroduction of herbaceous wetland plants and will stabilize lower slopes. An alternative species that may grow well once protection has been provided is wild rice (Zizania aquatica), and could be planted in clumps in this protected zone, or possibly from broadcast seeds. Approximately 13,800 total transplants will be needed for sprigging. Above elevation 441.5, several rows of willow and cottonwood cuttings should be placed on 18-inch centers until they are joined with the crest seeded area. In this more protected part of the barrier island, should Illinois and District game conservationists feel it is appropriate, some island areas could be left bare for use by resting birds. Over time, these areas would colonize with vegetation, and the bare ground condition would be temporary. Should more permanent bare ground areas be desired, placement of a gravel/sand cap on these areas would aid in preventing surface erosion and in holding back vegetation colonization.

If planting funds are limited for the project, the more protected side of the barrier island could be allowed to colonize naturally. However, allowances should be made for precipitation erosion during storm events and for freezing/thawing actions if this is the alternative selected for that side of the island.

c. The Small Islands in the East River.

Three smaller islands will be created from borrow material as the silt plug is removed and channel cut made in the East River (Figures J-1 and J-8). These islands will be located adjacent to and on either side of the East River channel, and vary in elevation above mean pool level (Figures J-4 and J-6). Major impacts on the easternmost island shown in Figure J-4 (left bank, descending) (hereafter referred to as Island 1) and on the westernmost island (right bank, descending) (hereafter referred to as the up-river portion of Island 2) shown in both Figures J-4 and J-6 will be from current action during river flood stage and from boat and barge wakes. The third small island shown in Figure J-6 (left bank, descending) (hereafter referred to as Island 3) will be impacted by wakes, currents, and

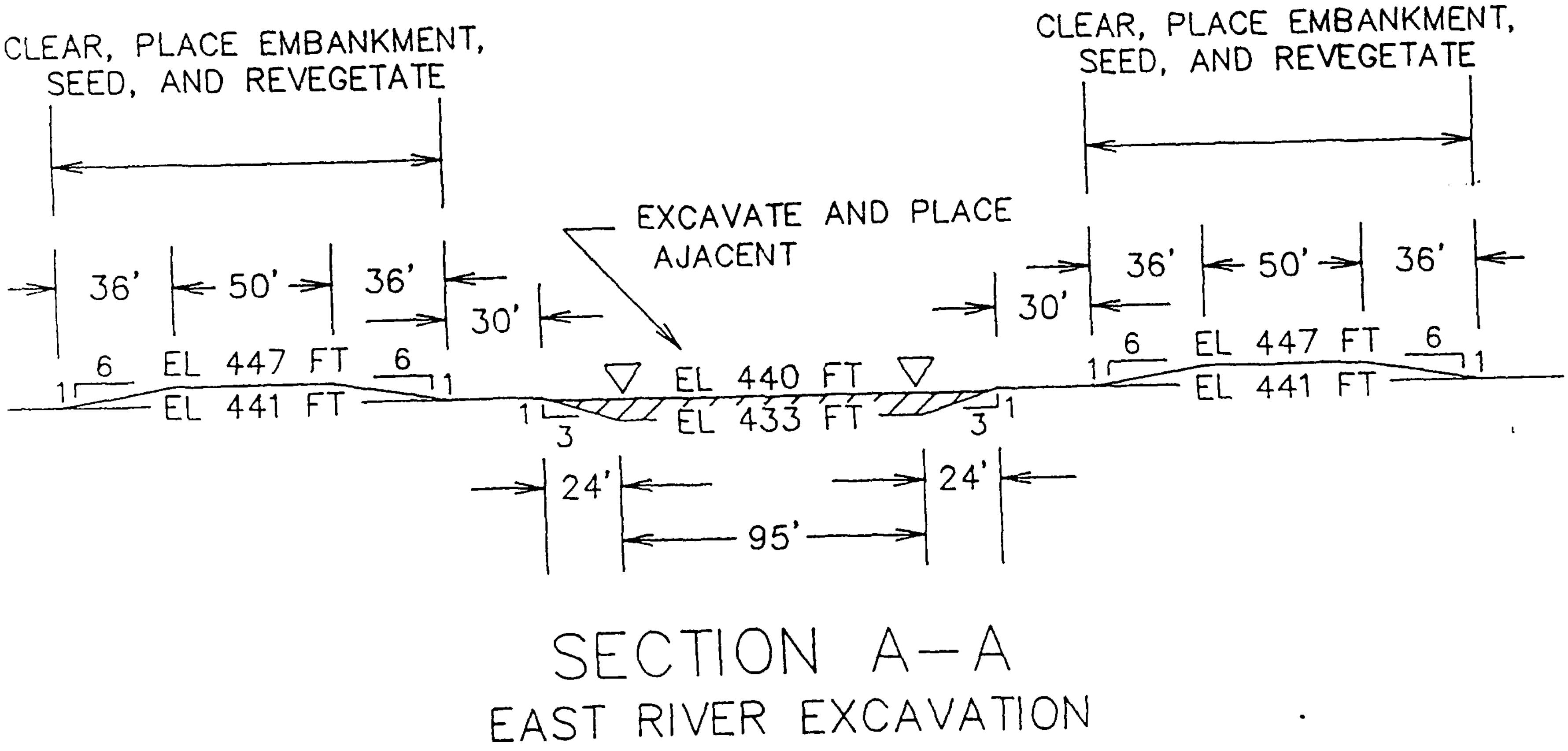


Figure J-4. A cross-section of Island I and the up-river portion of Island 2. Note that they are projected to be six feet above mean pool level.

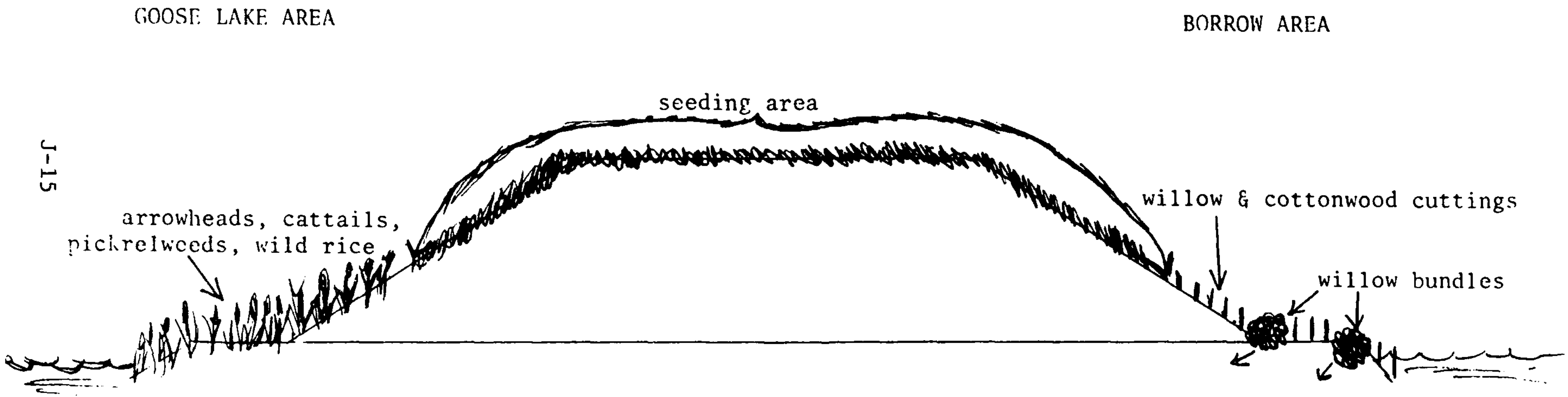


Figure J-5. A schematic cross-section of Island 1, showing planting zones. While the up-river portion of Island 2 is not depicted, vegetation and stabilization techniques are very similar, and are described in the text.

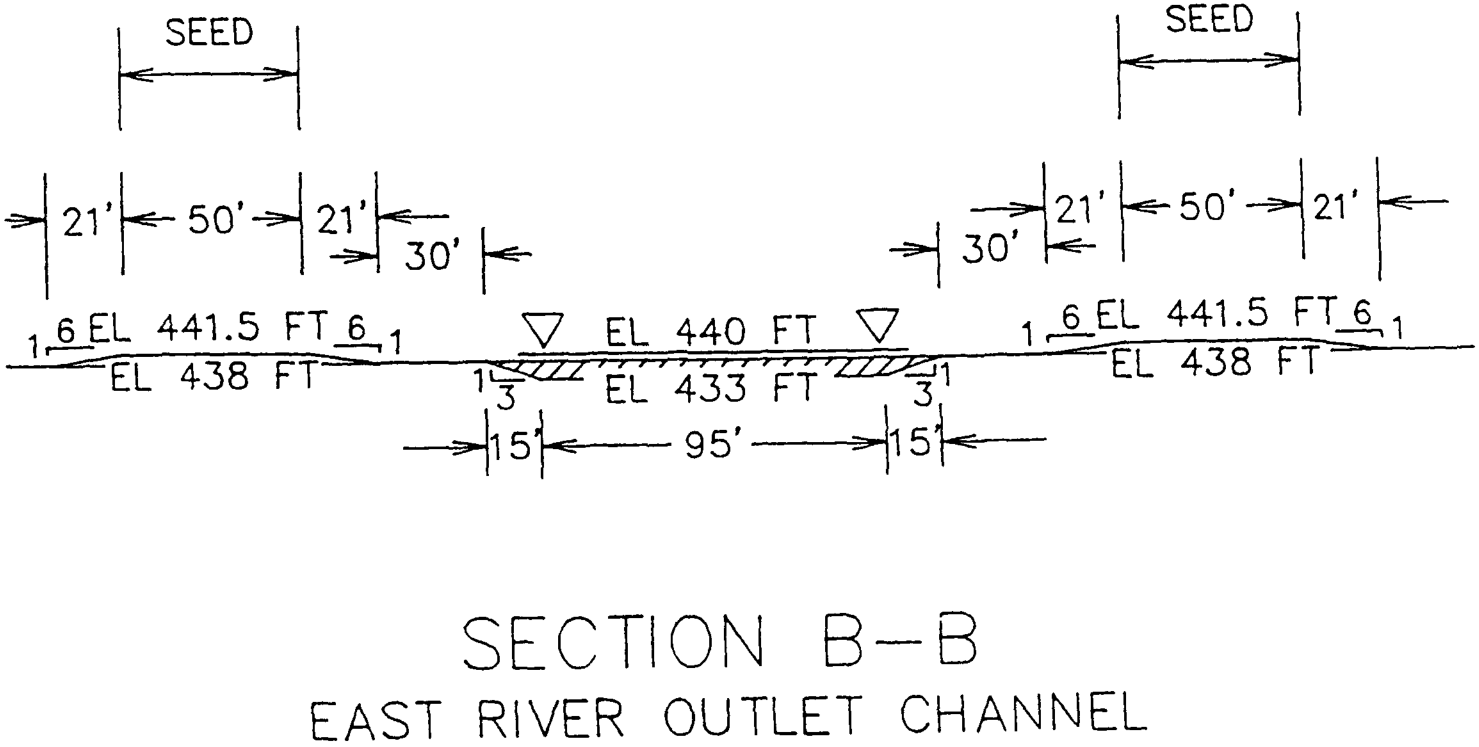


Figure J-6. A cross-section of Island 3 and the down-river portion of Island 2. Note that island height is only two feet above mean pool level.

wind-driven waves from Peoria Lake. In addition, crest elevations above mean pool level of Island 3 and the down-river portion of Island 2 change from 6 feet to 2 feet. Therefore, stabilization and vegetation recommendations will differ somewhat for the three islands.

(1) Island 1 and the Up-River Portion of Island 2.

At 6 feet above mean pool level, soil moisture conditions after dewatering should be very similar to the barrier island. There will be no need for placement of erosion-control matting at the shoreline of these islands, and the intent and purpose of this project is to stabilize these islands as rapidly as possible with typical riverine vegetation. On the channel side of both islands, willow and cottonwood cuttings are recommended on 18-inch centers from elevation 442 down to an elevation of 439 (1 foot below mean pool level) (Figure J-5). Island 1 is designed to be 2,200 feet long, and the up-river portion of Island 2 is 2,500 feet. This planting rate will require approximately 15,000 cuttings of all species. At the lowest elevation placement, some cuttings may not survive, but those that do will provide more rapidly a root mass to stabilize the toe of the islands. In addition, on the channel side, two parallel rows of willow bundles (long, live willow cuttings tied into bundles and buried into the slope substrate) could further ensure stabilization. Once buried, these cuttings readily sprout and root and form dense stands of willows. These should be placed at approximate elevations 440.0 to 441.0 (a 6-foot-wide area at 1:6 slopes) for maximum stability.

Crests of Island 1 and the upstream portion of Island 2 should be seeded with the same temporary grass cover as the barrier island as soon as it is completed. This may be followed later with the same more diverse seeding mixture used on the barrier island to ensure intermediate vegetation cover on the crests of Island 1 and the up-river portion of Island 2 while woody vegetation is beginning to grow and become the dominant island vegetation.

The up-river portion of Island 2 and the away slope of Island 1 will abut an existing river island, so it will not be necessary to plant cuttings on slopes there.

(2) Island 3 and the Down-River Portion of Island 2.

Island 3 is designed to be approximately 1,800 feet long, and the down-river portion of Island 2 will be 1,600 feet long (Figure J-8). Elevations and slopes indicated by Figure J-6 are lower and more subject to frequent overtopping by both mild flood levels and wind-driven waves from Peoria Lake. To a certain extent, these two areas are considered sacrificial (especially Island 3) protective barriers for the East River channel, since they are only 2 feet above mean pool level. The down-river portion of Island 2 abuts an existing river island for about one-half of its length.

Revegetation of these islands should be completed with willow and cottonwood cuttings, sprigged into the bare substrate on 18-inch centers (Figure J-7). Cuttings should cover from elevation 439 up to and over island

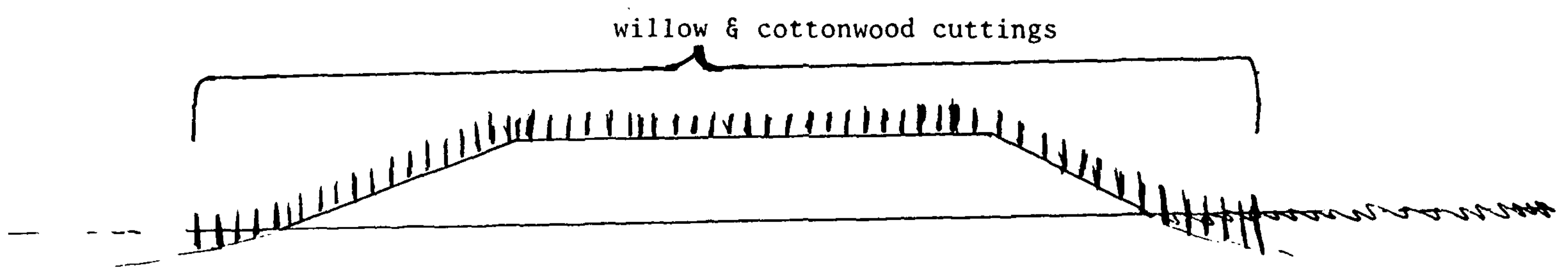


Figure J-7. A schematic cross-section of Island 3, showing planting zones. While the down-river portion of Island 2 is not shown, planting design is similar, and is described in the text.

crests. Where Island 2 abuts the existing island, cuttings should be placed up to the existing vegetation line. However, planting at these sites will require approximately 136,000 cuttings. Since these sites are considered sacrificial to some extent, plantings could be reduced to a spacing of 3-foot centers, which would reduce cutting requirements to an estimated 34,000, or only one-fourth the denser plant spacing. One other way of reducing the number of cuttings on sites that are not given the same importance as the barrier island and Island 1 is to not plant the island crests, but to allow them to colonize with vegetation on their own.

d. Floating Islands.

Once the island is completed and is providing protection to the shallow headwater area, the introduction of several aquatic plants could be accomplished by using plant propagules taken from Lake Carlyle or another lake in the vicinity. Illinois pondweed (Potomogeton illinoensis), other pondweeds, and water lilies (Nymphaea spp.) offer possibilities for floating and rooted aquatics. In very shallow still water, pickerelweed (Pontederia lanceolata), arrowhead, and softstem bulrush (Scirpus validus) are excellent rooted aquatic plant species choices that will grow in standing water. Killgore, et al., (1989) found that the number and diversity of fishes can be substantially higher in water with vegetation than in water devoid of plants. Reintroduction locations should be chosen carefully to provide the most protection and therefore the greatest chance of initial survival.

One means of accomplishing reintroduction could be with the use of floating vegetated structures. Hoeger (1988) reported on the routine use in Europe of floating vegetated islands in small lakes and ponds for a number of purposes: shoreline stabilization, water quality improvement, wildlife habitat, ecological landscaping, and biological purification. These islands are a commercial product (Bestmanm Ingenieur Biologie, West Germany) that are formed using welded piping up to 1 foot in diameter. They are triangular, but are approximately 8 feet on a side, and 26 to 30 inches high. They are floored and walled with polyethylene, polyurethane, or neoprene. The islands are filled with a ultra-lightweight soil mixture for planting (or a lightweight gravel substrate for resting waterfowl or waterbirds). They are planted while still either on shore or under best working conditions, then floated to the site by boat. Filled and planted, they weigh less than 100 pounds each. These islands can be strapped together to form a breakwater, or anchored individually, or both, depending upon wave and wind fetch conditions and amount of stability required.

The European floating islands can be modified for use in Peoria Lake by either being handmade from similar components or from biodegradable products such as logs or by finding a manufacturer willing to market such a product. Various sizes and shapes are entirely possible and could be tailored to address specific lake erosion problems. Costs would depend upon sources of islands, materials used, and size and shape of the floating islands built. The commercial islands are $1,000 each at the U.S. supplier location, undelivered and unassembled.

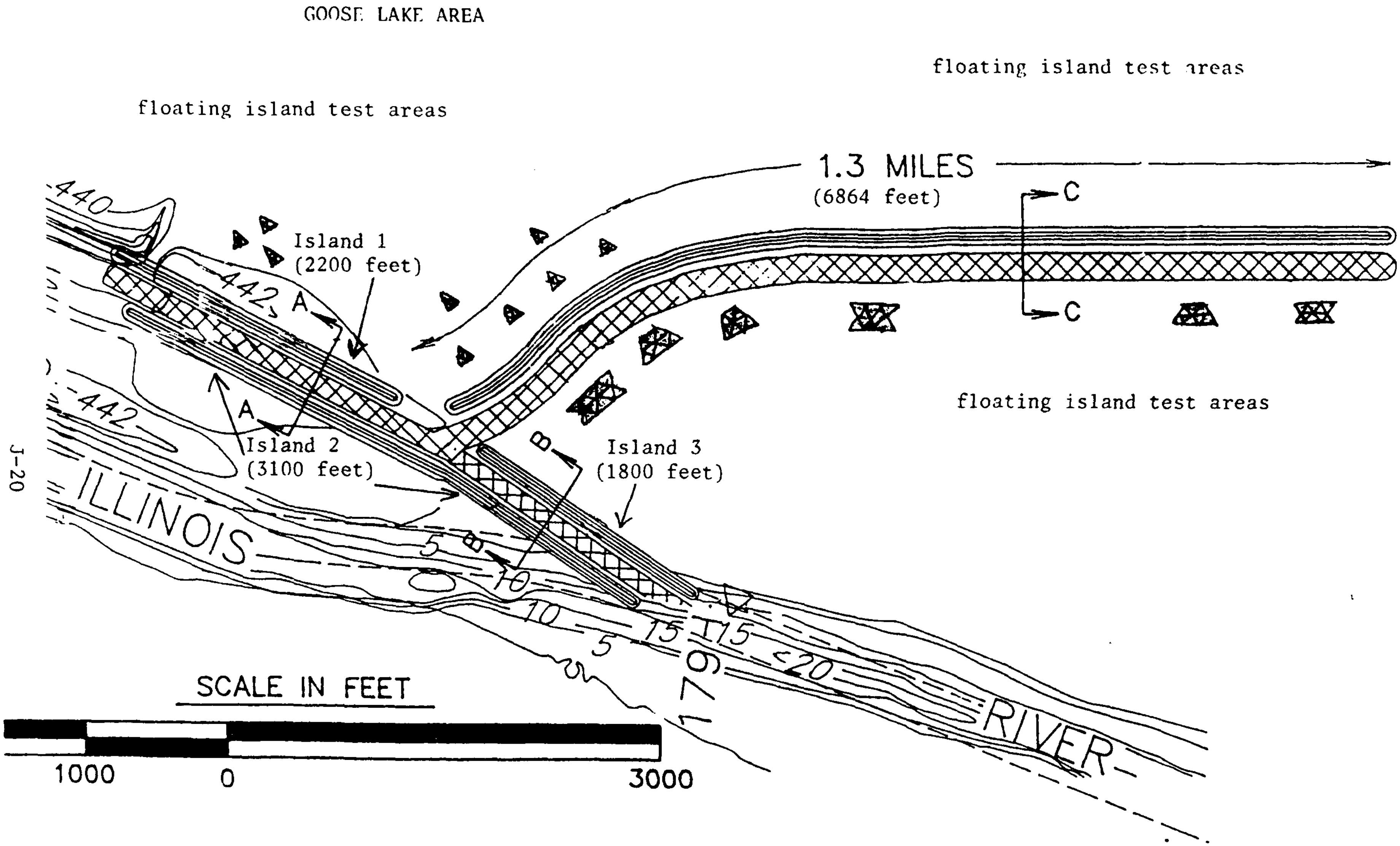
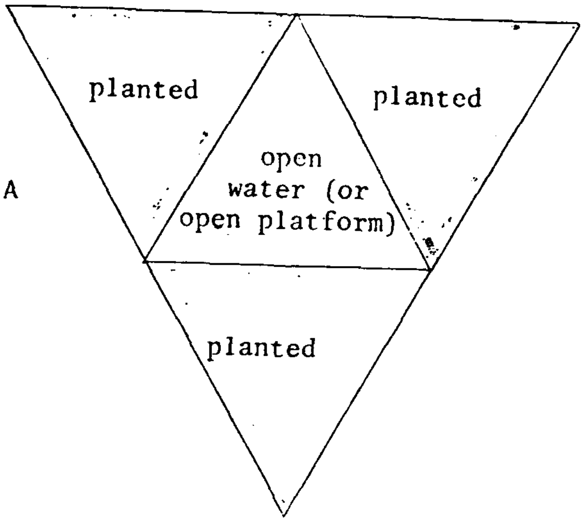
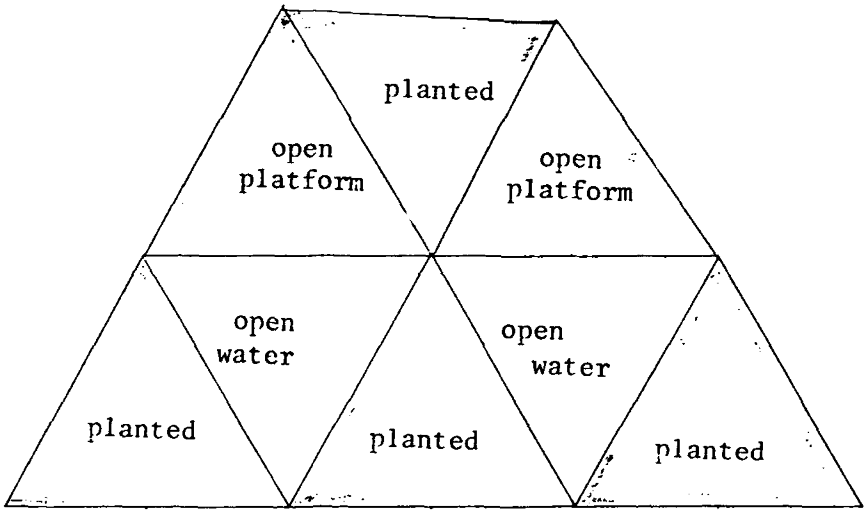


Figure J-8. A schematic showing details of the islands and the locations of test areas of floating island modules.

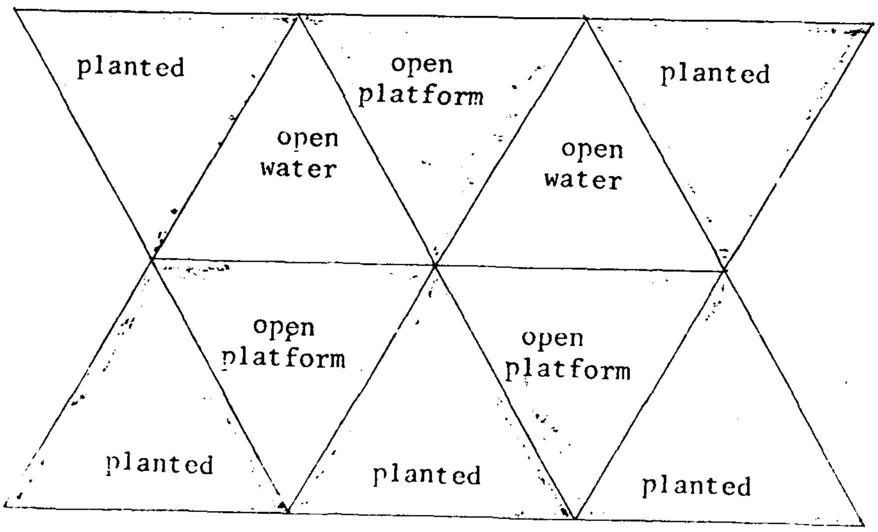
Figure J-9. A schematic of three possible configurations of floating island modules for testing at Peoria Lake. Configuration A is best suited for more protected areas in Goose Lake. Both Configurations B and C are suggested for tested on the borrow area side of the barrier island and in front of Island 3.



Configuration A



Configuration B (wind-fetch side)



Configuration C (wind-fetch side)

The extremely shallow water of Peoria Lake at the construction site would preclude use of the commercially-manufactured islands, because they are too deep (26-30 inches) to float in the lake. Therefore, innovation is necessary to make the island feasible for breakwaters and aquatic plant reintroduction in Peoria Lake. While the triangular shape could still be employed, islands would need to be not more than 15 to 18 inches deep to keep from being embedded in the substrate. Embedding in the substrate could possibly aid somewhat in overall stabilization; however, this would prevent one of the major objectives of the project: the provision of cover within plant root systems for aquatic biota. In addition, embedded islands would be overtopped by winter ice and spring floods, and damaged or destroyed.

At the Peoria Lake project, these islands could potentially be used in four areas: (a) as a breakwater between the borrow area and shoreline of the barrier island, (b) as a breakwater along the away slope of the borrow area, (c) as a breakwater in front on Island 3, and (d) interspersed in the slackwater area created behind the barrier island and Island 1 (Figure J-8). If option (b) is undertaken as a breakwater, the need for a breakwater for option (a) is lessened. Use of floating islands at Peoria would be considered experimental, and is recommended for several test locations to determine stability, growth of plants, effectiveness as a temporary breakwater, longevity, and ability to withstand ice and storm conditions. Islands should be planted with arrowheads, cattails, pickerelweeds and/or softstem bulrushes. Figure J-9 shows examples of three possible shapes and configurations; many other alternative designs are possible. Actual designs for testing should be determined prior to placement by a consensus of opinion of the Illinois State Water Survey, the Rock Island District, and WES.

The most difficult problem of using floating islands may be the effort of anchoring the islands in the soft foundation material found at Peoria Lake. Anchors must penetrate the bottom strata several feet deep to find a firm footing, or the islands may need to be attached to a piling driven into the lake bottom at each test location. Once a firm anchorage has been established at two points, the islands could be strapped together to form a breakwater from these two fixed anchorages. It is recommended that floating islands be positioned in options (a) and (c) at least 15 to 20 feet from the barrier island and Island 3 shorelines. Anchorage for options (b) and (d) will present similar problems, with the exception that wind fetch and wave action will not be factors in option (d). The broadest face of each floating island configuration should be used in options (a), (b), and (c) (figure J-9). This is to place the most durable face against the wind-driven waves of Peoria Lake. Islands containing vegetation will be interspersed with islands that serve as platforms and nesting sites and with open water cells within the overall configuration (Figure J-9).

The use of floating islands is preferable to tire breakwaters for aesthetic and environmental reasons. However, should an alternative and less expensive breakwater be considered for testing at a later time, construction of floating tire breakwaters similar to those used successfully by Twait

(1989) and by Allen et al., (1986), Allen (1988), and Allen and Klimas (1986) in several moderate wave energy situations is suggested. Several tire module configurations would be suitable at Peoria Lake; these have been used in other lake and estuarine situations and have been modeled to test efficiency in wave attenuation by the WES Hydraulics Laboratory. Twait's (1989) configuration is also one possibility for use with modifications to keep the tires floating. For example, while Allen injected styrofoam into the tops of tires and drilled a large hole in the bottoms to keep them floating, Twait did not use these extra features.

The effect of floating islands and breakwaters is to dampen waves and to allow plant growth (either planted or natural colonization) to occur in the shallow water and along the shoreline. As with the floating islands, anchorage of the tire breakwater could be a major problem in the soft substrate. Disadvantages of tire modules are that they could sink over time from collecting sediment, or that they could break anchor and ride up on the shoreline vegetation or drift in Peoria Lake. This also may be a problem with floating islands, but they have not been used enough in this country to know how they will function in a lake environment. Hence, a small pilot study is suggested to test them in Peoria Lake.

Tire breakwaters have been tested under icy conditions by Twait and found to withstand being under winter ice with no problems. Floating islands may ride out icy conditions, but this is also currently an unknown. Advantages of tire breakwaters are that they are generally free for the asking in nearby cities, and costs are only for labor to construct tire modules and for strapping and anchoring materials.

Initial costs of stabilization versus the loss of the island from erosion make stabilization feasible and necessary. Traditional riprap solutions would be difficult due to the softness of the substrate, and it is suggested that the less-costly bioengineering alternatives and options discussed above be considered for all or part of the proposed island shoreline.

e. The Borrow Area and Aquatic Habitat Development.

Gravel has been used to create fish habitat (Stuart 1953; Edwards, et al., 1984) and to accelerate biological recovery in streams modified by channel development (Shields 1983). Habitat creation techniques in navigable waterways are simple, operationally feasible, and should be considered when appropriate material and a suitable site is available. These habitats can be built with sediment from maintenance dredging which often reduce material transportation costs. When incorporated into early planning, aquatic habitat development can satisfy environmental concerns and meet project purposes.

Construction of the barrier island in Peoria Lake will create a borrow area measuring approximately 224 feet wide by 14 feet deep and 1.3 miles long (Figure J-2). An additional length of borrow area will be created when the East River is deepened to allow navigation (this material will be the basis for the other three islands). Both of these borrow areas are projected to have a slope of 1:3. WES recommends that two sites within the overall East River borrow area be covered with a "blanket" of gravel and sand from an underwater deposit in the East River or from another source.

Hydraulic surveys indicate that adequate velocities exist in the East River, especially after the silt plug is removed, to allow viable gravel bed habitats. Figures J-10 and J-11 indicate placement and shape of the proposed rock blankets. While the borrow area at the barrier island also may be suitable in slope for rock blankets, this borrow area will be likely to silt in relatively quickly and, therefore, is not recommended for such habitat development.

Gravel will be obtained from nearby sources to construct the two rock blankets in the East River. Both will be constructed above the upper cut in the East River in the area of greatest current velocities (Figure J-10). Each will measure approximately 45 feet wide by 300 feet long and will be 2 feet thick. One rock blanket (gravel bar) will be constructed of a 50-50 mixture of medium sand and gravel (1.0 to 3.0 inches in diameter). The second rock blanket (gravel bar) will consist of 50 percent medium sand, 25 percent 1- to 3-inch gravel, and 25 percent cobble or rock (i.e., particles up to 10 to 12 inches in diameter). Approximately 1,100 cubic yards of material will be required to construct each habitat (2,200 cubic yards total of sand, gravel, and cobble).

Gravel will be transported to the site by barge and placed with a clam shell dredge. The gravel barge will be held in place with spuds, by securing to the shore, or by securing to a small work boat. The area for placement will be delineated with buoys placed only along the offshore side of the habitat. The crane operator will estimate the width of the bar (45 feet) by the length of his boom. The materials barge will be positioned at the up-river extent of the proposed bed, then gravel will be spread evenly as the work boat moves down river. The operator will open the bucket slowly as he sweeps the area to ensure an even distribution of material. In addition, the operator will ensure that propeller wash does not disturb the newly placed material. The condition of the bars will be determined during, or immediately after, placement of materials by SCUBA divers as described in Task I in post-construction monitoring. Total time to construct the East River rock blankets, including placing the buoys and conducting the initial inspection, will take approximately 2 to 3 days. The newly created rock blankets will be allowed to colonize naturally with freshwater mussels. However, as an option, certain species could be transplanted to the new habitats after the gravel has been in place for at least 6 or more months. This would ensure that the habitats are colonized by mussels, and also would help to stabilize the newly placed gravel. Common species that could be brought to the habitat are three-ridge (<u>Amblema plicata</u>), heel-splitter (<u>Potamilus alatus</u>), maple leaf (<u>Quadrula quadrula</u>), and three-horn warty back (<u>Obliquaria reflexa</u>).

If transplanting mussels to the rock blankets is decided upon, the total length of transplanted mussels should be measured and an identifying number

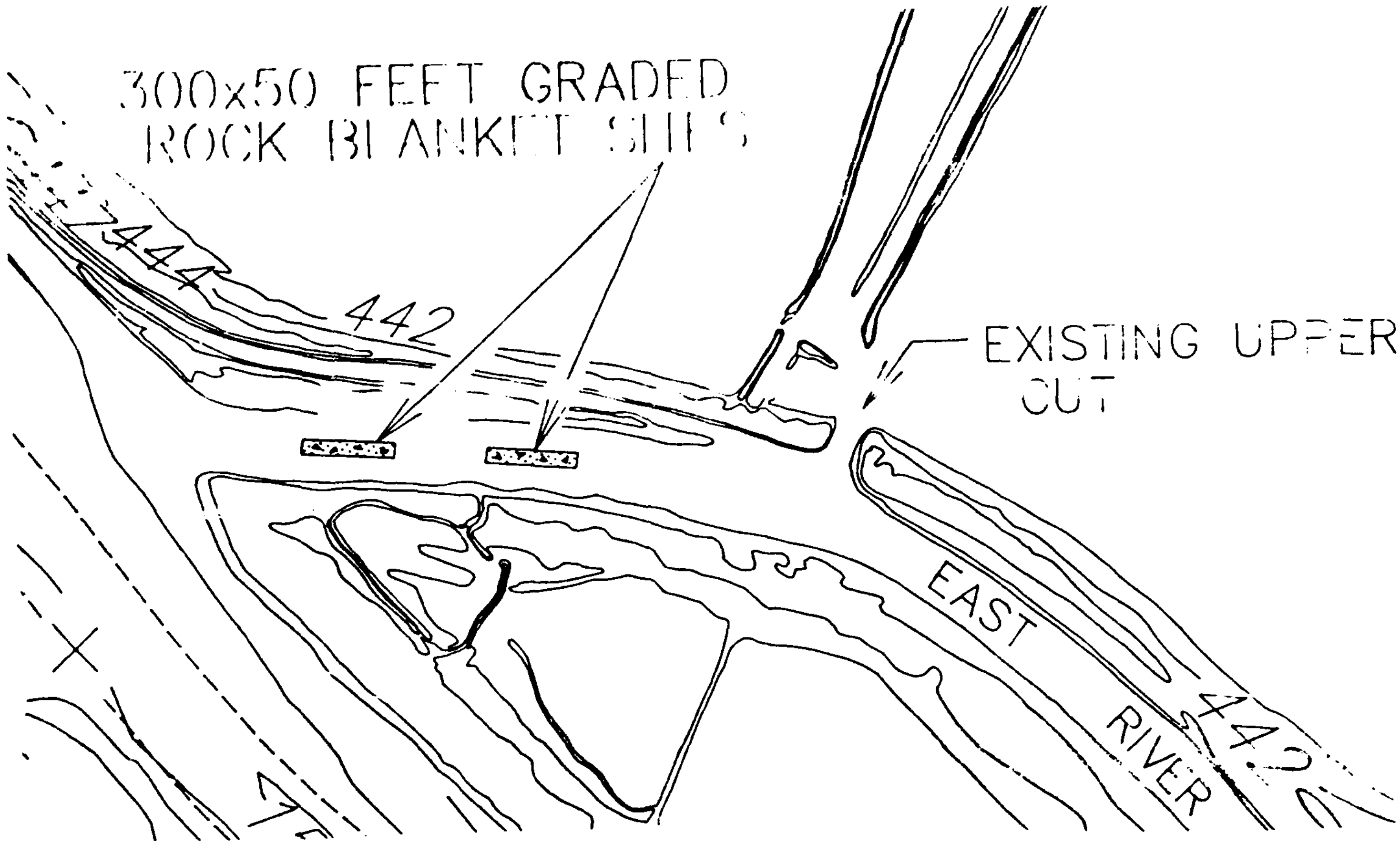


Figure J-10. A schematic showing the location of the two rock blankets up-river from the existing upper cut, in the area of highest velocity in the East River.

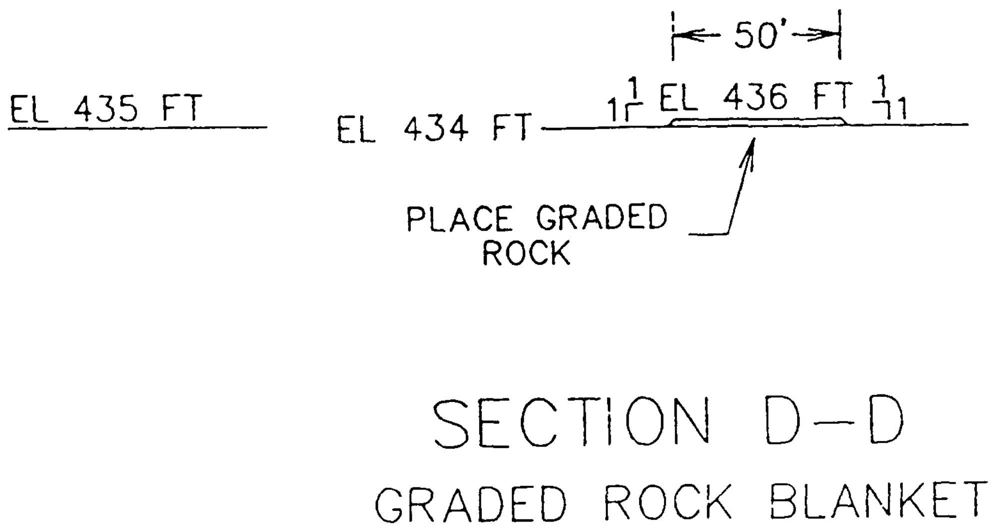


Figure J-11. A cross-section showing the placement and projected change in bottom topography in the East River through placement of two rock blankets.

should be engraved in the periostracum. To ensure that mussels can be recovered (to determine mortality and growth), at least some should be placed in 0.25-square-meter aluminum quadrats at each rock blanket that are partially buried in the substrate. It would be wise not to transplant uncommon or endangered species to the sites for several years, because the rock blankets should be completely stable prior to such introduction.

f. Use of Habitats by Wildlife, Aquatic Invertebrates, and Fishes Wildlife.

Waterfowl use of aquatic habitats has been well documented over many years by a number of researchers and wildlife managers (Bellrose 1976, Schemnitz 1980). Whether summer residents raising broods or migratory flocks, ducks and geese are attracted to floating and rooted aquatic beds where they feed on stems, leaves, roots, and seeds of aquatic plants. During egg laying and brood rearing, waterfowl rely heavily on the invertebrate populations in aquatic vegetation to provide needed protein for egg production and rapid growth of ducklings and goslings. It is expected that waterfowl will be observed using the still water area (Goose Lake) provided behind the barrier island and Island 1 as well the borrow area for feeding and resting.

Rapidly vegetating the four manmade islands will aid greatly in their stabilization, while also providing cover and food for wildlife. Primary users of these islands are expected to be waterfowl, especially on the barrier island (nesting mallards (Anas platyrhynchos) and wood ducks (Aix sponsa), feeding migratory and summering ducks), other water-related birds, muskrats and other furbearers, and reptiles and amphibians. The floating islands also should provide good resting sites for waterfowl.

Wildlife use of the barrier island could be enhanced by the erection of wood duck and hooded merganser (Lophodytes cucullatus) nesting boxes, small nesting boxes that may be used by warblers, wrens, and other cavity nesters, and by the provision of a few open gravel and sand areas on the crest of the islands that may attract nesting terns and shorebirds. It is cautioned that these open areas for nesting would not remain unvegetated, however, without active management and vegetation removal. It is further cautioned that wetland plantings will be highly attractive to feeding water fowl and may require protection until shoreline vegetation has become well established. There are a number of techniques for protection known, including screening, flagging, and other scare tactics, and temporary exclusion devices that have been used at other Corps projects, that will be suggested by WES if the need arises.

Since the other three islands will be connected or very close to the mainland, no enhancement of these sites to attract nesting birds is recommended. Any such concentration of nesting waterfowl or waterbirds would attract nest predators, which would have easy access to these three islands.

(1) Invertebrates.

The deep water of the borrow areas will provide little habitat for macroinvertebrates. These organisms require coarse-grained particulates; usually gravel or cobble are the preferred substrates (Hynes 1974). However, if oxygen was at sufficient concentrations for most of the year (at least 4 mg/l), then a community of oligocheate worms and chironomids would be expected to occur. These invertebrates will provide food for fishes. However, it is unlikely that the new deep-water habitat will provide any additional habitat for macroinvertebrates that does not already exist in Peoria Lake.

The rock blanket to be constructed from medium-sized particles will provide habitat for freshwater mussels, aquatic worms, and immature midges which are found in slack to moderately flowing water (i.e., 0.2 to 1.5 feet/sec). The rock blanket constructed from sand, gravel, and cobble will provide habitat for immature caddisflies, mayflies, and other organisms which can tolerate rapidly flowing water (greater than 0.5 foot/sec). However, mussels, aquatic worms, and aquatic insects also will be found at this rock blanket gravel bar with the coarse-grained materials.

The rock blanket constructed with 25 percent coarse-grained materials will be placed at an area in the East River where water velocities exceed 2.6 feet/sec. The bar constructed with finer-grained materials will be placed down river from the first blanket at a location where water velocities range between 1.4 and 1.7 feet/sec. These water velocities will provide sufficient current to keep the blankets free of fine-grained materials (Vanoni 1975). Water velocities will decline to less than 0.2 foot/sec at these gravel bars during certain periods of the year. However, during high flow the fine-grained, recently deposited materials will be swept off the gravel substrate. It is unlikely that brief periods of sediment accumulation will be detrimental to the benthic invertebrates.

(2) Fishes.

The project will affect three primary habitat variables that influence the distribution and abundance of fishes: depth, velocity, and substrate. These variables have been identified as important in structuring fish communities in a variety of stream ecosystems (Becker 1983; Gorman and Karr 1978; Leonard and Orth 1988; Ross 1986). An increase in water depth around the island will provide deep water refugia during winter ice conditions and increase usable habitat area by fishes that prefer deeper water such as crappie (Corophium spp.), drum (Aplodinotus grunniens), and buffalo (Ictiobus spp.) An increase in water velocity along the side channel of the east river will provide flowing water habitat for many riverine fishes such as johnny darters (Percina maculata) and common redhorse (Moxostoma aureolum). Creation of the gravel bar, particularly using a gradation of sizes including flat rocks and cobble, will provide suitable substrate for obligate riverine fishes that require these conditions for shelter from predators, as well as spawning, rearing and feeding areas. Maintaining a diversity of depths, water velocities, and substrate types should lead to substantial improvement in the quality of the aquatic fauna.

Additional habitat features also are considered. For example, the placement of riprap at selected bank locations along the river shoreline and new islands may provide direct benefit to some fishes. Riprapped banks often contain higher numbers of fish than natural banks (Pennington, et al., 1983; Farabee 1986). However, loosely placed, large-diameter stones appear to provide a fish habitat that is superior to that formed by smaller, tightly placed stones (Farabee 1986).

Establishment of aquatic plants is desirable. By decreasing the turbidity behind the island, macrophytes may become established. There is also a possibility of revegetation using plants discussed in previous sections. There are a number of possibilities for plant species diversity in a planted habitat, some of which are recommended in the three previously discussed island sections. It is expected that fish use of such vegetated areas in Peoria Lake will increase dramatically, based on prior experience in other lakes and rivers where this has occurred (Killgore, et al., 1989).

Since turbidity and high levels of suspended solids greatly interfere with fish feeding, movement, migration, spawning, and species diversity (Alabaster 1985), reduction of wind fetch behind the island should enhance fisheries habitat. High sedimentation adversely effects the quality of aquatic habitat in several ways. Silt increases turbidity, which, in turn, decreases light penetration that inhibits phytoplankton and aquatic macrophyte growth (Hynes 1970). Direct effects on fish include abrasive injuries to delicate external organs such as gills, fins, and protective mucal coverings, or smothering eggs and nests. Indirect effects can range from elimination of a preferred food source to elimination of preferred reproductive habitat for fish and aquatic invertebrates.

J-3. MONITORING.

What determines if an environmental project is a success? Careful assessment and statement of project objectives during planning are important not only to determine what a project is to accomplish, but to have a basis for determining if, in fact, the project did accomplish what was intended. The project objectives for this Peoria Lake project stated in the EIS generally provide for environmental enhancement in Peoria Lake, especially in the improvement of fisheries and waterfowl habitat. A major project objective is to remove the silt plug from the East River to provide for navigation, while at the same time using the dredged material for habitat enhancement. The following paragraphs give some indication of the biological productivity and habitat expectations for Peoria Lake.

No habitat development project can be complete without monitoring the development of the vegetation, wildlife, fish, and invertebrate use of the project. Monitoring and evaluation are useful to the Corps in determining whether the project meets intended objectives, provides the quantity and quality of habitat intended, and/or provides improved overall environmental conditions in Peoria Lake. Monitoring will provide baseline data that will be available for use for future Peoria Lake and other similar projects. It will provide "lessons learned," both from an engineering and an environmental design and construction standpoint, and as an example of what worked and what did not, how to reduce expenses in such projects, and how to develop such aquatic and island habitats under moderate wave energy conditions. WES recommends that a combination of District and State biologists and engineers make site evaluations and conduct post-development monitoring, and offers technical assistance in evaluation if requested.

a. Evaluating the Success of the Manmade Islands.

Prior to any site construction, it is recommended that Habitat Suitability Index Models (HSI) for key species by used to assign habitat values before habitat development. The District and State have already made preliminary assessments of wildlife enhancement during project pre-planning to determine anticipated habitat units. They used mallards and catfish as target species, with eight others considered as non-target species: green-backed heron (Butorides virescens), wood duck, beaver, northern parula (Parula americana), pronothonotary warbler (Protonotaria citrea), northern pike (Esox lucius), bluegill (Lepomis pallidus), and johnny darter.

Fish HSI guild models already have been developed and used at the request of Rock Island District. Key water-related wildlife species with excellent HSI models that also could be assessed both prior to and after construction include wood ducks, mallards, and muskrats.

Initial biological monitoring of the barrier island is based on general, established Corps minimum monitoring criteria for habitat development sites (Landin, et al., 1989a). These monitoring criteria were developed over a period of 14 years from numerous techniques or were modifications of existing textbook sampling techniques that were practical in dredging projects. Monitoring would consist of observations along several permanent transects established from the outer edges of the erosion control matting (underwater) up onto the planted island crest. On an island 1.3 miles long, at least six such transects are needed. For the first growing season, monthly observations are recommended. In the second growing season, bimonthly monitoring is adequate. In subsequent seasons, annual monitoring is sufficient. In addition, site visits in fall, winter, and spring are needed to document wildlife and fisheries use and to observe any physical changes due to ice and storms when vegetation is dormant.

Vegetation monitoring should be nondestructive, i.e., no extensive plant samples collected for further analysis. A minimum of five randomly placed 3-foot-square quadrants along each transect line need to be established to provide adequate statistical data. In each quadrant, vegetation data collected generally will consist of survival, species composition, colonization in unplanted quadrants, natural invasion in planted quadrants, stem height, stem density, percent cover, and seed production. In addition, general observations of vigor, color, and signs of stress or other qualitative information will be noted.

(1) Task I: Initial Inspection.

At each of the two rock blankets in the East River, a SCUBA diver will measure gravel thickness at 5 to 10 locations and determine the approximate shape and size of each blanket. The corners will be marked with iron stakes and a reference cable (thin, coated airline cable) will be placed along the center of the blanket and secured with rebar. This will be done to assist in orienting divers on subsequent surveys.

(2) Task II: Preliminary Inspection.

This task will be conducted in the early spring of the year immediately following completion. Divers equipped with SCUBA or surface air supply will inspect physical and biological conditions at each rock blanket. This will consist of: (a) making an inspection of the blanket (visually and by feel) to determine areas of sediment accretion and erosion; (b) collecting 5 to 10 sediment samples for analysis of grain size and total organic content; (c) collecting 5 to 10 samples to visually inspect for the presence of small clams and macroinvertebrates; and (d) searching the substrate for the presence of mussels.

The results of this task will be used to determine the need for future studies. If no biota are found during this inspection, then there will be no need to initiate Task III, IV, and V monitoring, and a repeat of Task II inspection will be necessary the following year until colonization has been noted. It is likely that four or more years may pass before juvenile mussels will be found, although fish use would be more likely in less time.

(3) Task III: Macroinvertebrates.

To obtain information on general macroinvertebrates and fishes using the blankets, observation needs to begin during the first season following construction. The level of detail outlined below is considered the minimum level needed to determine actual use of the rock blankets and aquatic habitats. At each of three sites (located at the upper, mid-point, and lower portion of the bar), 10 quantitative samples will be collected with a hand-held coring device (Miller and Bingham 1986).

Samples will be preserved in the field and returned to the laboratory for processing. Each sample then will be elutriated a total of five times to separate organisms and other biological materials from the coarse-grained sediments. Coarse-grained materials (which may include some organisms) and the elutriated materials will be separately preserved in 70 percent ethyl alcohol. For 5 of the 10 samples, all organisms will be removed from the elutriated sample and placed in major groups (i.e., total chironomids, total oligochaetes, etc.). The organisms from the remaining five elutriated samples will be identified to the lowest possible taxon. In addition, two to three of the samples of sand and gravel will be searched for live organisms. This latter step will be completed to determine if the

Outside of permanent transect lines, general documentation of survival and growth of seeded areas on the island crest (temporary cover) and colonization and growth of permanent vegetation will be noted. Data collection will include date of colonization, general abundance, species diversity, and other general vegetation data such as estimated growth rate on woody plants and apparent ability to hold island soil (stability).

General wildlife use during all site visits will be recorded and used to compile a cumulative species list that includes type of use, habitat observed, species diversity, numbers, and feeding and other behavioral patterns over the entire monitoring period of several years. Of special note should be the use of the island by waterfowl, since this is the group of species of primary concern in Peoria Lake. Since wildlife data are important components missing from the existing baseline data for Peoria Lake, these data would be valuable additions to the central Illinois environmental data base.

As a possible alternative to, or addition to, establishment of transects and measured quadrants, a less labor-intensive (and, therefore, less expensive) monitoring technique for wildlife is to establish one or more fixed observation points on the barrier island. These are used by one or more observers with binoculars and/or spotting scopes for fixed periods of time during each site visit to record wildlife observations. They also would be used as fixed photography points to visually record changes over time.

Use of fixed observation points eliminates the need for walking transects for most wildlife, although it biases observations towards birds and mammals. Rodents, reptiles, land invertebrates, and most nesting birds will be missed using this sample technique. If a level of monitoring is desired that includes these species and documentation of nesting on the constructed island, establishment of transects and other techniques will be needed to adequately document occurrence, abundance, and nesting data.

It will not be necessary to conduct intensive monitoring of the other three islands created by the removal of the silt plug in the East River. Rather, general observations of wildlife use of these islands at the same time of monitoring on the barrier island can be made and will be sufficient to establish general uses and trends.

b. Evaluating the Success of the Rock Blanket Habitats.

Biological and physical conditions at each of the newly completed habitats can be assessed through completion of six tasks. Task I will be completed immediately after construction, and Task II will be conducted in the spring of the first year immediately following construction. Depending upon the results of this investigation, Task II studies could be repeated as deemed appropriate by the District and the State for several years. Based on the results of Task II, additional studies (i.e., Tasks III-IV) could be initiated and are outlined here for long-term planning purposes.

elutriation process has missed large numbers of individuals (more than 10 percent), or specific taxa.

The data from the above sample processing techniques can be used to determine total macro-invertebrate density and total density of major taxa at each site (N=10). In addition, relative species abundance, species richness, species diversity, and evenness can be determined for the five remaining samples.

(4) Task IV: Fishes.

The shallow, turbid environment of Peoria Lake has limited the distribution of fishes. This environmental harshness eventually causes diversity to decline as the tolerances of some species are exceeded (Thiery 1982). Therefore, colonization rates of the created habitats will be variable. Common species such as bluegill, drum, and some minnows are expected to inhabit the borrow areas and rock blankets initially. Further colonization should occur, and depends upon behavioral motility, relative generation times of the organisms involved, distance from the source of the colonizers, and the quality of the physical/chemical conditions (Gore 1985, Neuhold 1981).

The relative importance of the project to fishes will be determined by comparing fish assemblages in the borrow areas and East River rock blankets to unaltered backwater and flowing water reaches of the river, respectively. A comparison site for the barrier island will be selected and will consist of a shallow, backwater area subject to high sedimentation and turbidity levels. A comparison site for the rock blankets also will be selected and will be located in an area with similar depth and velocity characteristics, but with substrate consisting of clay, sand, or silt. Fishes will be collected both day and night during a period of intensive sampling to evaluate temporal utilization of the habitats. This also will ensure that the majority of fishes will be accounted for in each of the habitats.

Fishes will be collected in the borrow areas and the comparison site with an electroshocking boat. The entire periphery of the island will be sampled and an equivalent effort (amount of shocking time) will be expended at the comparison site. Seining will be used to collect fish in the river sites. At least 10 seine hauls will be made at both the rock blankets and the comparison site reaches at each sampling time to document species composition and abundance. All fish collected will be identified by species, total length will be measured, and they will be released.

Catch per unit effort (CPUE) will be calculated and compared among sites. Taxonomic composition also will be compared among sites using indices of similarity and diversity. Qualitative similarity, which compares taxonomic composition of two species lists, will be measured using the Jaccard index. Values range from 0.0 (no species in common) to 1.0 (all species shared), represent simple percentages, and are relatively unbiased by sample size (Ludwig and Reynolds 1988). Quantitative similarity, which compares relative abundance of different species in two collections, will be measured using the percent similarity index as recommended by Schoener (1968). Values range from 0.0 (assemblages completely distinct) to 1.0 (assemblages identical), and accurately estimates overlap with no bias from numerically-dominant taxa (Magurran 1988). Diversity will be quantified using the reciprocal of the Simpson index (1/D), which evaluates numerical dominance and provides discriminate ability with low sensitivity to sample size (Magurran 1988). Values range from 1.0 (all individuals in a single taxon) to N (individuals evenly distributed among all species).

(5) Task V: Mussels.

SCUBA divers will search for mussels at approximately 10 sites on each blanket during each sampling period. At each site, the diver will search a specific area and obtain mussels recognized by touch. If mussels are uncommon, the diver will obtain all live specimens encountered within a specific time period (i.e., 15 to 20 minutes). If mussels are more common, then specimens will be collected in increments of 10 or 20; at least 200 mussels will be obtained at each site under commonly occurring conditions. These results will provide information on the presence of rare species and the relationship between sampling effort and number of species present (Isom and Gooch 1986; Kovalak, et al., 1986; Miller and Payne 1988). After the mussels are counted and identified, they will be returned to the river. Information on water depth and velocity, distance to shore, and six sediment samples for determination of grain size and organic content will be obtained.

Based on this information, two to three permanent sites will be identified and recommended for additional quantitative studies. Quantitative studies then will be conducted at these sites. Quantitative samples will be obtained by having a diver collect all substrate within a 0.25-square-meter quadrat. Sediment will be brought to the surface and sieved through nested screens with mesh size ranging from 3.0 cm to 5 mm. Live mussels will be removed and preserved in buffered formalin. They will then be identified, counted, and shell length and wet mass determined. If time permits, mussels will be processed alive and returned to the river unharmed. These techniques will enable collecting the following data on mussels: total density (as well as density of the more common individual species), relative species abundance, evidence of recent recruitment and subsequent growth, total species richness, species diversity and evenness, and presence of uncommon species. In addition, selected individuals can be preserved and data can be determined on shell mass and length, tissue dry mass, and age at first fecundity. Interpretation of these parameters can provide additional data on the health and condition of individual species, and on the overall benefits of the rock blankets and deep water habitats provided by the borrow areas.

(6) Task VI: Waterfowl.

The major task effort under aquatic habitat for waterfowl and other wildlife will be to document feeding by waterfowl during the nesting season and during migration. Quantitative data on amounts of invertebrate food and vegetation available for waterfowl consumption will require harvest of standing floating and rooted submergent vegetation (assumed to harbor invertebrates) in 10 randomly selected 3-foot-square plots within the area where aquatic plants have been introduced or have colonized the protected areas around the floating islands, the islands' shorelines, and the still water areas in Goose Lake.

In all areas where aquatic plants are introduced or have colonized, 10 plots each are recommended as samples in April, June, August, and October during the first and second growing seasons, and seasonally in subsequent years. Data to be collected would include plant species diversity, percent cover of vegetation, and reproduction. In addition, a pound of plant material (wet weight) would be removed from each of the 10 plots in each aquatic area and carried back to the laboratory in closed containers for closer examination for aquatic insects and other invertebrates that are generally fed upon by waterfowl broods and hens. A Berlese Funnel would be used remove aquatic insects from the plant material for analysis. The estimated biomass of insect and other invertebrate material can be extrapolated using the total plant biomass estimated on the plots and the actual biomass found in a pound of vegetation. All invertebrates found will be identified by family or order. The relative abundance of these small prey items will be recorded.

There are other techniques for determining waterfowl food habits in a particular area, including examination of gizzard and crop contents. However, there is no way to determine if digestive system contents from migrating waterfowl came from Peoria Lake or from the previous area in which they had fed. For purposes of this study, the simple monitoring techniques outlined above are adequate and relatively inexpensive.

c. Determining Overall Habitat Improvements from the Project.

A number of "markers" or thresholds indicate that a project is providing quality habitat and is meeting project objectives. Some of these are outlined below, and are recommended for consideration at Peoria Lake.

(1) Macroinvertebrates.

Presence of Representative Fauna. Each rock blanket habitat should support at least three or more species characteristic of physical conditions at the habitat. For example, at sites with water velocities in excess of 0.5 foot/sec, it is anticipated that caddisflies (Trichoptera) and mayflies (Ephemeroptera) would be found. In more depositional areas, it is anticipated that oligochaete worms (Oligochaeta) would be found in areas with little or no flow in the summer.

Presence of a Diverse Fauna. Each rock blanket habitat should support at least a moderately diverse fauna that includes representatives of functional groups of scrapers, filter-feeders, predators, and gatherers.

(2) Fishes.

Representative Species. The rock blankets should support species that prefer flowing water over gravel substrate such as johnny darters and common redhorses. The borrow areas should provide habitat for larger, predatory fishes of commercial and recreational importance such as largemouth bass (Micropeterus salmoides), buffalo, and catfish.

Species Richness and Diversity. Comparison of species richness (total number of species should be higher in the rock blankets and borrow areas due to added habitat heterogeneity). For the indices described above, there are a certain range of values to indicate that a diverse fish fauna exists. Composition of the fish fauna is considered similar among sites if the values are greater than 75 and 60 percent for the Jaccard and percent similarity value (PS), respectively. High values generally indicate that there is a high degree of homogeneity, often due to the widespread distribution of most species within the system. However, low value would indicate that the fish fauna are distinctly different among locations, indicating that the created habitats support different species. A Simpson diversity index less than 3 indicates low diversity, while a value greater than 5 indicates high diversity.

(3) Mussels.

Presence of 10 or More Species. Quantitative and qualitative sampling at the rock blankets should yield at least 10 species of mussels. It is understood that some of these may be uncommon and represent less than 1 percent of the assemblage.

Evidence of Recent Recruitment for Five or More Species. The results of quantitative sampling should yield juveniles (defined here as individuals less than 1.2 inch total shell length). It is understood that some of these species (i.e., Truncilla truncata, Carunculina parva) may be quite small as adults.

(4) Waterfowl and Other Wildlife.

Wildlife use will occur on the barrier island and other manmade islands, on the floating islands in the pilot study, and in the aquatic habitats created by protection from wind and wave action. Habitat diversity is the key to large numbers of species and abundance of species within a project such as Peoria Lake. This diversity is provided by the development of a large island, three smaller islands, a number of small floating island groups offering protection on their lee sides, and the development of open water areas with introduced aquatic plant propagules.

Birds. Documentation within the project area of occurrence and abundance by season of key indicator water-related birds and mammals for Peoria Lake will give an indication of success. It is expected that mallards, wood ducks (if nest boxes are provided), Canada geese (Branta canadensis, other duck species during migration, great blue herons (Ardea herodius), great egrets (Casmerodius albus), green-backed herons, belted kingfishers, least bitterns (Ixobrychus exilis), American coots (Fulica americana), and other water-related birds will be found. Several species of swallows during migration, and bank swallows (Riparia riparia) and barn swallows (Hirundo rustica) during the nesting season, should be observed. Water-associated birds such as common yellowthroats (Geothlypis trichas), some warbler and flycatcher species, and blue-gray gnatcatchers (Polioptila caerulea) should occur when vegetation on the island reaches heights and densities that these species prefer. As many as 60 species may be observed during spring and fall migration; however, at least 30 species should be noted as an indicator that habitat diversity has occurred.

On the barrier island, and possibly on the floating islands, mallard nests may be found. It is not likely that ground-nesting ducks will nest on the other three islands. In addition, on all four islands, nests of water-related birds such as the yellowthroat may occur.

Nest density data in these cases are not as important in measuring project success as hatching and brood rearing data. For example, if wood duck boxes with predator guards are installed on the barrier island, it is expected that a minimum of 50 percent of the boxes should be occupied by nesting hens within 2 years of box installation.

These boxes should not be placed without firm intentions of an active management program to keep boxes clean, in good repair, and free from nest predators.

Mammals. Small mammals, especially furbearers such as muskrats, beavers, and river otters, should be expected to occur on the four islands and to be observed in the aquatic areas. Muskrats and beavers are not affected by turbidity and low fish populations, but these species require an adequate supply of edible vegetation and a safe area in which to dig dens or erect houses. River otters at the proposed island site will not occur unless fish populations increase to a level that will satisfy requirements of a pair or a family of otters. The presence of river otters in the project area would be a prime indicator of the quality of aquatic habitat being provided. However, the presence or absence of river otters on the project site may not be due to limited prey items and may be a factor of low river otter populations and lack of recruitment into Peoria Lake. Care should be taken in assessing reasons for presence or absence of any wildlife, especially furbearers with trapping pressure and wading birds whose nesting colonies may be too far away to efficiently fly to Peoria Lake during breeding season to feed.

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HABITAT ASSESSMENT AND QUANTIFICATION

APPENDIX K

UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
DEFINITE PROJECT REPORT
WITH INTEGRATED ENVIRONMENTAL ASSESSMENT (R-6F)

PEORIA LAKE ENHANCEMENT
PEORIA POOL, ILLINOIS WATERWAY, RIVER MILES 178.5 TO 181

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APPENDIX K
HABITAT ASSESSMENT AND QUANTIFICATION

K-1. PURPOSE.

The purpose of this appendix is to present an overview and the results of the process used for quantification of habitat benefits for this enhancement project. Recommendations for further refinement of the models also are presented. The method was applied by an interagency team composed of staff from the Illinois Department of Conservation (IDOC), the U.S. Fish and Wildlife Service (USFWS), and the U.S. Army Corps of Engineers.

K-2. BACKGROUND.

The need for quantification of EMP-HREP outputs has been discussed by various agencies associated with the EMP as a project performance evaluation tool, a project ranking tool, and a project planning tool. This application involves quantification solely for the purpose of project planning.

The benefits to be derived from habitat rehabilitation and enhancement projects are not readily convertible to actual monetary units as is customarily required for traditional benefit-cost analyses. A method of quantification is needed to adequately evaluate project features for planning, design, and administrative purposes.

Measurable changes in habitat value can be described by suitability indices, habitat units, animal numbers, or animal use days.

The selected approach is referred to as a Habitat Unit (HU) accounting methodology. Several similar methodologies exist at this time, such as Habitat Evaluation Procedures (HEP), which was developed by the USFWS as an impact assessment tool; Habitat Evaluation System (HES), which was developed by the Corps of Engineers also as an impact assessment method; and Habitat Management Evaluation Method (HMEM), which was developed by the Bureau of Reclamation. Of the three methodologies referenced, HEP is likely to be the most familiar to all participants in the EMP.

K-3. METHODOLOGY.

a. Nomenclature.

Habitat Unit (HU) - (Acreage of a particular habitat type) * (HSI value). HUs represent a numeric estimate of usable habitat for particular species within a defined area.

Habitat Suitability Index (HSI) - Index of habitat quality or suitability for particular species derived by a numeric ranking of life requisite characteristics at selected sample sites.

Average Annual Habitat Unit (AAHU) - AAHUs represent an average HU value based on annualization of HUs over a series of selected Target Years (TY). AAHUs account for changes in habitat values over the life of a project.

Average Annual Habitat Suitability Index (AAHSI) - Similar to AAHUs, HSI values can be averaged and annualized over the life of the project to account for changes in habitat quality over time.

b. General Procedure.

For this project, HUs were chosen as the unit of comparison for project features or alternative plans. HUs are derived by multiplying habitat acreages by habitat quality, determined by HSIs. HSIs result from numeric ranking of site characteristics at sample sites throughout a given project area.

Numeric ranking for terrestrial and wetland habitat values was accomplished using the existing Wildlife Habitat Appraisal Guide (WHAG) field data sheets for forested and non-forested wetlands and a computer program developed by the Missouri Department of Conservation (MDOC) and the U.S. Soil Conservation Service. A brief example of site characteristics is listed below.

WHAG Site Characteristics for Forested and Non-Forested Wetlands

Percent of the study area non-forested wetland
Percent of the study area lake or reservoir
Water level control
Substrate conditions
Average water depth
Emergent vegetation coverage
Vegetative species diversity
Size of the wetland
Percent of the area covered by food plants
Woodland size class and canopy coverage
Ratio of mudflats to permanent water
Hydrologic conditions
Number of cavity trees

Extent of forest openings
Understory density and diversity

Aquatic habitat types and associated fisheries benefits were generated using a newly developed draft Aquatic Habitat Appraisal Guide (AHAG) compiled by the Rock Island District, Corps of Engineers, with input from the MDOC, the USFWS, and the Corps of Engineers Waterways Experiment Station.

Founded on the same principles as the terrestrial habitat models, the aquatic guide is a numerical quantification of HUs based on the quality of a given aquatic habitat and the affected acreage of that habitat type. While additional models will incorporate numerous target species and a range of aquatic habitat types, the Peoria Lake project only evaluated one target species, the channel catfish, in one particular habitat, side channel habitat. The characteristics for side channel habitat evaluation include a combination of physical and chemical determinations, vegetation patterns, and overall productivity (see list below). Consistent with the WHAG methodology, each habitat characteristic is ranked and assigned an associated numerical value. Calculations then can determine the existing quality of a particular aquatic habitat for a specific target species of fish; in this case, channel catfish. The target species is representative of those species of fish which prefer similar environmental conditions and share similar life requisites, namely slackwater areas out of the main channel currents. Vegetation, woody debris, and deeper pooled areas are additional factors considered for this guild of fish which includes members of the catfish family, as well as bass, crappie, buffalo, pike, and threadfin shad.

<u>Side Channel Aquatic Habitat Characteristics</u>

Instream cover
Aquatic vegetation
Channel depth
Productivity
Velocity
Shoreline characteristics
Dissolved oxygen
Air temperature
Spawning habitat
Streambank condition
Substrate
pH
Total dissolved solids
Forage base
Turbidity
Water temperature
Width of side channel

Computer results are provided for estimated total HUs and calculated HSI values for the forested and non-forested components of the project (development of an aquatic habitat appraisal guide software program is under way). After existing conditions are determined, the study team reviewed the habitat appraisal guides to determine where habitat quality can be improved. HUs were annualized for target years using the USFWS's HEP 80 program in order to evaluate changes in project features over time.

Habitat quality ratings can be improved by: (1) increasing acreages for particular habitat types that may be limited or lacking; (2) altering a limiting factor, such as unpredictable water levels; (3) altering a management strategy such as cropping practice, or cover crop composition; or (4) a combination of the preceding, depending on management goals, target species requirements, or available funds.

Project goals for habitat enhancement include improving wetland values for migratory waterfowl and increasing fisheries resources through aquatic side channel restoration. Therefore, the study team selected the appraisal guides for wetland habitats, with the mallard as a target species or species of emphasis. As was mentioned above, the aquatic component of the project was evaluated using the newly developed side channel model with the channel catfish target species. Prior to site sampling, the study team reviewed aerial photography, topographic maps, and preliminary design drawings to select representative sample sites for WHAG application. In addition, waterfowl census information and fisheries data from recent surveys was also reviewed.

During site sampling, assumptions were developed regarding existing conditions and projected post-project conditions, relative to limiting factors and management practices.

K-4. ASSUMPTIONS.

a. Turbidity limits aquatic plant establishment in Upper Peoria Lake.

b. Turbidity results from wind and wave generated resuspension of unconsolidated bottom materials.

c. Water levels throughout the project area are unpredictable during waterfowl migrations. Lack of water level control limits wetland value during migrations.

d. Alternatives evaluated represent available options to modify habitat suitability for migratory waterfowl, as represented by the resource categories of forested wetland, non-forested wetland, cropland, and grassland.

e. Target years of 0, 1, 25, and 50 will be sufficient to annualize HUs and characterize habitat changes over the estimated project life.

f. The mallard is a suitable species of emphasis and adequately characterizes life requisite requirements of the migratory waterfowl group for the purpose of incremental analysis of this project.

g. The muskrat, wood duck, green heron, northern parula, and prothonotary warbler are suitable species for evaluation of overall wetland values and changes in wetland values resulting from project construction.

h. Resource-partitioned guilds of fish (Killgore) may be represented by individual species which are suitable for evaluation of overall aquatic habitat values and changes in aquatic habitat values.

i. The life requisite information for the channel catfish is suitable for characterization of side channel habitat and may be used for evaluation of changes in side channel conditions.

K-5. RESULTS.

Alternatives evaluated at the Goose Lake site included No Action, water level management in forested areas, barrier island creation, and side channel restoration.

The inter-agency WHAG/HEP team assessed the existing conditions of the project area utilizing the field evaluation sheets for each of the habitat types within the project area. The results are presented in table K-1, as Annual Habitat Units, Average Annual Habitat Units (AAHUs), and Average Annual HSI (AAHSI) values for the selected Target Years (TY) for the Forested Wetland Management Area and the Barrier Island Creation. The WHAG analysis evaluated selected target species, including mallard, in several habitat types to derive a representative picture of the existing conditions at Woodford County Conservation Area. Future conditions without construction of the project were predicted for target years 25 and 50 based on the existing conditions, successional changes in the habitat over time, and any management practices that may be implemented with or without the proposed project.

The remainder of this section provides the numerical assessment, while Section K-6 provides the narrative interpretation of the analysis.

a. Forested Wetland Management Area.

The mature silver maple association forest encompassed by the Woodford County Conservation Area is typical of the forest community along the Illinois River. Using the bottom land hardwoods matrix for the proposed FWMA, an HSI value of 0.43 for mallard was calculated for the existing conditions of the area. The local biologists felt that the HSI values were representative of the area due to its present value for waterfowl and its use during the migration seasons. Nongame species HSI values were significantly lower than 0.43 for all but the northern parula, which had an HSI value of 0.48 (table K-3). The team then numerically predicted the future without-project conditions within the project area using the same bottom land forest matrix. It was determined that even with successional changes in the forest, the quality of the area for mallard probably would not change significantly over the 50-year project life. Therefore, an HSI of 0.43 would be adequate. However, successional changes in the forest canopy over time would affect the habitat of parulas. With increased canopy openings over time, the HSI value for parulas would increase to 0.73

(table K-4), while the remaining target species' HSI values would remain about the same.

As is evidenced in the FWMA TY01 and TY50 portions of table K-1, the HSI value for mallards shows a significant increase immediately following construction of the levees (HSI-0.79) and a continued increase over the life of the project (HSI-0.85), while the remainder of the target species values are relatively unaffected.

b. Barrier Island Construction.

The location of the proposed barrier island is presently a shallow open water zone of Goose Lake below Chillicothe Island. Evaluation of the existing and future conditions for the barrier island creation was accomplished using the non-forested wetland matrix and field sheets. Results of the WHAG indicate that the HSI value for mallard in Goose Lake is only 0.11, whereas HSIs for heron and yellowlegs rank considerably higher at 0.75 and 0.69, respectively (table K-7). The numerically predicted future HSI values probably will not change significantly over time without the creation of a barrier island.

However, the creation of a man-made barrier island results in a gradual improvement in the quality of aquatic habitat over time as the vegetation becomes established behind the island. By target year 25, the HSI value for mallard will improve to 0.45, and by target year 50 the overall increase in quality will be to an HSI value of 0.65.

c. Side Channel Excavation.

At present, the East River channel is an existing side channel with incoming flows being diverted through a lower opening in the side channel known as Mt. Hope cut.

The results of the draft AHAG application indicate that excavation of the side channel opening to restore flow will increase habitat suitability from 0.41 to 0.62 for the channel catfish target species. However, given the channel's past history of siltation, maintenance dredging is scheduled for Target Year 25 to keep the channel open and maintain the 0.62 HSI value for the East River channel habitat. An additional increase in HSI value, to 0.77, can be realized by the addition of gravel beds in the channel and the placement of the rock fill in the upper cut of the channel.

Opening the silt plug will restore the original side channel flow conditions and create an additional 7 acres of side channel habitat that is now lost to the silt plug and debris in the lower outlet of the channel.

K-6. DISCUSSION.

This section is intended to interpret the numerical results of the WHAG analysis into a narrative format that will provide insight as to how the numbers were derived and what they mean in terms of the predicted outcome of the project.

Results of WHAG application for the proposed alternatives were compared as increments to costs associated with implementation of each alternative plan. This incremental analysis is discussed in the Definite Project Report in Section 6 - Evaluation of Alternatives.

A 60-day migration season multiplier was used to calculate a sum total AAHU value for comparison against the cost figures in the incremental analysis. This value is referred to as AAHU* in the Detailed Project Report.

a. Forested Wetland Management Area.

The greatest overall improvement in wetland habitat values for the FWMA would be accomplished through predictable water level control. Much of the food resource produced within the FWMA now is available only to migrating waterfowl during periods of high water in the fall. However, through the construction of levees and control structures, a manageable level of water can be ponded on the area, greatly increasing its value to waterfowl. Management of the water regime on the FWMA in the spring of the year allows natural moist soil plant species, (i.e., smartweed) or planted cereal grains (i.e., millet) to become established. Thus, the value of the food plant resource is increased, along with its availability. The combination of these two primary improvements in the habitat of the FWMA will increase the HSI value by almost 100 percent by TY 50 (HSI=.85).

Incremental analysis of the FWMA feature involved selecting the most economical design which generates the most benefits in terms of HUs. In this case, 1-, 2-, and 3-celled designs were evaluated against each other and against the without-project condition. The 3-celled design provided AAHUs of 137 over the 50-year life of the project, while the without-project condition would only generate 79 AAHUs. A 1- or 2-celled configuration would generate significantly less AAHUs and at a higher overall cost. Therefore, the 3-celled design was the preferred design. In addition, further justification for the 3-celled configuration lies in the depth of the water ponded within each cell. Given the layout of the existing ground contours, a 3-celled area also will maximize the area of ponded water depth between 1 to 24 inches which is ideal for dabbling ducks like the mallard.

b. Barrier Island.

Waterfowl values for non-forested wetlands in the Goose Lake area are limited by the lack of rooted aquatic vegetation. Wind and wave action contribute to both mechanical and physiological inhibition of aquatic vegetation, which is reflected in the extremely low HSI values for the non-forested wetland matrix (table K-1). Under the without-project condition, the values essentially remain unchanged over the projected 50-year life of the project. The constant pounding of waves from wind fetch in the shallow waters will continue to limit aquatic vegetation in the area. However, construction of a barrier island will result in a significant reduction in the amount of wind-generated waves and associated turbidity. The estimated 1,000-foot wind shadow created behind the island will promote the establishment of rooted aquatic vegetation along the leeward side of the island by Target Year 5. The associated HSI value of 0.43 represents almost a 300-percent improvement in the habitat quality 5 years after construction. A predicted domino effect of colonizing vegetation behind the island results in the Target Year 50 HSI value of 0.65; an increase of almost 500 percent in qualitative improvements in wetland values for the Goose Lake area.

The incremental evaluation of three lengths of island (0.5, 0.9, and 1.3 miles) was compared against dredging costs to determine habitat values at the different lengths. Benefits for the wind shadow behind the island will accumulate in a linear fashion, thereby making the cost the limiting factor. The WHAG team decided to include a qualitative approach to benefit quantification for the barrier island. An average annual habitat suitability index (AAHSI) value of 0.52, in addition to the AAHU value was calculated for the 50-year life of the project. By Target Year 50, the succession of woody cuttings planted on the island into a mature bottom land forest community will have resulted in a well established forest canopy. The added height of the forest canopy will further magnify the extent of the quiet zone behind the island. Therefore, a TY50 HSI value of 0.65 has been estimated for the barrier island non-forested wetland behind the island. This represents a 490 percent increase in the quality of habitat within the Goose Lake area of Woodford County.

c. Side Channel Excavation.

The East River side channel excavation presents a unique opportunity to restore valuable side channel environs. Utilizing the newly developed draft AHAG matrix for channel catfish, the WHAG team determined that the existing habitat values were considered fair to poor (HSI= 0.41). The flow within the channel presently exits through a cut in the side channel due to the closure of the natural opening. However, with restoration of the side channel opening to the main channel, improvement in parameters such as current velocity, channel depth, pH, and turbidity result in an improvement of the HSI value to 0.62. The increased diversity in habitat created by the addition of a rock substrate in the channel generates additional benefits which are reflected in the final HSI value of 0.77. Translated into HUs, the existing side channel has an HU value of 8. Excavation of the silt plug and restored flow conditions will improve the quality of the entire side channel habitat. In addition, the actual excavation of the silt plug itself will create an additional 6.4 acres of aquatic habitat. Thus, the total HU value of the side channel is increased to 24 HUs. Qualitative improvements, in combination with the increased acreage of aquatic habitat, constitute a 140 percent increase in the HU value of the East River.

Since the dimensions of the side channel opening were designed to meet hydraulic requirements, incremental analysis was not used to compare dredging quantities and equipment operation cost to increases in habitat value. Rather, pre- and post-project conditions were compared to evaluate the significance of the side channel project feature.

K-7. CONCLUSION.

For this project HU accounting using WHAG/HEP provides adequate quantification necessary to portray planning and design rationale of habitat enhancement projects.

Based on this application of WHAG, HU accounting forms a sound basis for alternative evaluation and output optimization. Further application of this methodology and refinement is being pursued in the interest of nontraditional projects and their success.

Several opportunities for modifications to the WHAG methodology were encountered during the development of the Peoria Lake project. The following recommendations are being evaluated for completion of the draft AHAG models and refinement of the existing WHAG models.

Further modification of the AHAG models may include age class variables: spawning, rearing, adult and development of additional aquatic models for additional lentic and lotic habitats.

One qualitative factor that is not displayed through application of the draft AHAG methodologies is the overall rarity of side channel habitat in the Illinois River. It is especially important as overwintering habitat for species that are displaced from shallow channel border habitat and forced to seek refuge in main channel areas. Winter navigation is considered to reduce or eliminate the value of deep main channel habitat for most species of fish. By providing contiguous deep habitat, the side channel opening with rock placement is considered to be a highly significant improvement in aquatic habitat in the Peoria Pool. The significance of this improvement may not have been revealed during use of the draft AHAGs.

An important factor that needs to be incorporated into the WHAG methodology is a component for the refuge aspect of projects which indeed serve as managed areas for fish and wildlife. It was evident to the WHAG team that further refinement in the model was needed when the team attempted to calculate animal numbers expected for a given habitat acreage. According to the mallard model, the Goose Lake area rated extremely poor for waterfowl. However, census information gathered over the past 10 years indicates quite the contrary (Appendix L - Habitat Inventories). In actuality, the Goose Lake area, as well as Woodford County Conservation Area, serves as a refuge for migrating waterfowl. Food plots, as well as natural food sources in the immediate vicinity of Woodford County, provide limited feeding areas, while the Goose Lake area provides the resting and loafing area. Therefore, the low HSI value derived from the matrix is accurate from a food resource standpoint due to the limited vegetation, but the area is highly valuable as a refuge area.

In conclusion, the WHAG methodology in conjunction with an incremental analysis approach to project feature design, determined that a three-celled FWMA will provide increased diversity of habitat in the Woodford County Conservation Area while the barrier island will improve wetland vegetation patterns in Peoria Lake, and excavation of the East River channel will restore needed side channel habitat on the Illinois River.

TABLE K-1

Average Annual Habitat Units
Peoria Lake HREP - January 1990

TARGET SPECIES
MALLARD

	TY 0			TY 1			TY 2 - TY 25			TY 26 - TY 50			
	HSI	Area	Annual HUs	HSI	Area	Σ Annual HUs	HSI	Area	Σ Annual HUs	HSI	Area	Σ Annual HUs	AAHUs
Plan A - Without Project	0.43	183	79	0.43	183	79	0.43	183	1889	0.43	183	1967	79
Plan B - Forested Wetland - Cell A Only	0.43	63	27	0.79	63	38	0.85	63	1240	0.85	63	1339	52
Plan B - Forested Wetland - Cell B Only	0.43	53	23	0.79	53	32	0.85	53	1043	0.85	53	1126	44
Plan B - Forested Wetland - Cell C Only	0.43	49	21	0.79	49	30	0.85	49	964	0.85	49	1041	41
Plan B - Forested Wetland - Cells B & C	0.43	102	44	0.79	102	62	0.85	102	2007	0.85	102	2168	85
Plan B - Forested Wetland - Cells A+B+C	0.43	165	71	0.79	165	101	0.85	165	3247	0.85	165	3506	137

	TY 0			TY 1			TY 2 - TY 5			TY 6 - TY 50			
	HSI	Area	Annual HSI	HSI	Area	Σ Annual HUs	HSI	Area	Σ Annual HUs	HSI	Area	Σ Annual HUs	AAHSI
Plan C - Island Creation - Without Project	0.11	1	0.11	0.11	1	.11	0.11	1	.44	0.11	1	4.95	0.11
Plan C - Island Creation	0.11	1	0.11	0.12	1	.12	0.45	1	1.80	0.65	1	29.95	0.52

WHAG ANALYSIS FOR THE FORESTED WETLAND
MANAGEMENT AREA AND BARRIER ISLAND CREATION

TABLE K-2

Habitat and Species Abbreviations

WILDLIFE HABITAT APPRAISAL GUIDE

HABITAT TYPE ABREVIATIONS

1	N	NONFOREST WETLAND
2	B	BOTTOMLAND HARDWOODS-WETLAND
3	C	CROPLAND-WETLAND
4	G	GRASSLAND-WETLAND

SPECIES ABREVIATIONS

1	MALL	MALLARD	7	HERO	GREEN-BACKED HERON
2	GOOS	CANADA GOOSE	8	DUCK	WOOD DUCK
3	BITT	LEAST BITTERN	9	BEAV	BEAVER
4	YLEG	LESSER YELLOWLEGS	10	COOT	AMERCIAN COOT
5	MUSK	MUSKRAT	11	PARU	NORTHERN PARULA
6	RAIL	KING RAIL	12	PROT	PROTHONOTARY WARBLER

TABLE K-3

PROJECT NAME: PEORIA LAKE HREP
FORESTED WETLAND MANAGEMENT UNIT
TARGET YEAR 00 EXISTING CONDITIONS

SAMPLE SITE HABITAT INDEXES

HAB	SITE	MALL	GOOS	BITT	YLEG	MUSK	RAIL
B	1	.43					
		HERO	DUCK	BEAV	COOT	PARU	PROT
		.13	.15	.11		.5	.16
HAB	SITE	MALL	GOOS	BITT	YLEG	MUSK	RAIL
B	2	.43					
		HERO	DUCK	BEAV	COOT	PARU	PROT
		.13	.16	.12		.45	.16
HAB	SITE	MALL	GOOS	BITT	YLEG	MUSK	RAIL
G	6		.14				
		HERO	DUCK	BEAV	COOT	PARU	PROT

THIS DATA SET CONTAINS:
0 NONFOREST WETLAND SAMPLE SITES
2 BOTTOMLAND HARDWOODS-WETLAND SAMPLE SITES
0 CROPLAND-WETLAND SAMPLE SITES
1 GRASSLAND-WETLAND SAMPLE SITES

AVERAGE HABITAT INDEXES BY HABITAT TYPE

HAB	MALL	GOOS	BITT	YLEG	MUSK	RAIL	HERO	DUCK	BEAV	COOT	PARU	PROT
N												
B	.43						.13	.16	.11		.48	.16
C												
G		.14										

TABLE K-4

PROJECT NAME: PEORIA LAKE HREP
FORESTED WETLAND MANAGEMENT UNIT
TARGET YEAR 50 WITHOUT PROJECT

SAMPLE SITE HABITAT INDEXES

HAB	SITE	MALL	GOOS	BITT	YLEG	MUSK	RAIL
B	1	.43					
		HERO	DUCK	BEAV	COOT	PARU	PROT
		.13	.16	.14		.75	.14
HAB	SITE	MALL	GOOS	BITT	YLEG	MUSK	RAIL
B	2	.43					
		HERO	DUCK	BEAV	COOT	PARU	PROT
		.13	.16	.15		.7	.13

THIS DATA SET CONTAINS:
0 NONFOREST WETLAND SAMPLE SITES
2 BOTTOMLAND HARDWOODS-WETLAND SAMPLE SITES
0 CROPLAND-WETLAND SAMPLE SITES
0 GRASSLAND-WETLAND SAMPLE SITES

AVERAGE HABITAT INDEXES BY HABITAT TYPE

HAB	MALL	GOOS	BITT	YLEG	MUSK	RAIL	HERO	DUCK	BEAV	COOT	PARU	PROT
N												
B	.43						.13	.16	.14		.73	.14
C												
G												

TABLE K-5

PROJECT NAME: PEORIA LAKE HREP
FORESTED WETLAND MANAGEMENT UNIT
TARGET YEAR 01 WITH PROJECT

SAMPLE SITE HABITAT INDEXES

HAB	SITE	MALL	GOOS	BITT	YLEG	MUSK	RAIL
B	1	.79					
		HERO	DUCK	BEAV	COOT	PARU	PROT
		.14	.15	.11		.5	.16
HAB	SITE	MALL	GOOS	BITT	YLEG	MUSK	RAIL
B	2	.79					
		HERO	DUCK	BEAV	COOT	PARU	PROT
		.14	.16	.12		.45	.16
HAB	SITE	MALL	GOOS	BITT	YLEG	MUSK	RAIL
G	6		.14				
		HERO	DUCK	BEAV	COOT	PARU	PROT

THIS DATA SET CONTAINS:
0 NONFOREST WETLAND SAMPLE SITES
2 BOTTOMLAND HARDWOODS-WETLAND SAMPLE SITES
0 CROPLAND-WETLAND SAMPLE SITES
1 GRASSLAND-WETLAND SAMPLE SITES

AVERAGE HABITAT INDEXES BY HABITAT TYPE

HAB	MALL	GOOS	BITT	YLEG	MUSK	RAIL	HERO	DUCK	BEAV	COOT	PARU	PROT
N												
B	.79						.14	.16	.11		.48	.16
C												
G		.14										

TABLE K-6

PROJECT NAME: PEORIA LAKE HREP
FORESTED WETLAND MANAGEMENT UNIT
TARGET YEAR 50 WITH PROJECT

SAMPLE SITE HABITAT INDEXES

HAB	SITE						
HAB	SITE	MALL	GOOS	BITT	YLEG	MUSK	RAIL
B	1	.85					
		HERO	DUCK	BEAV	COOT	PARU	PROT
		.13	.14	.13		.75	.14
HAB	SITE	MALL	GOOS	BITT	YLEG	MUSK	RAIL
B	2	.85					
		HERO	DUCK	BEAV	COOT	PARU	PROT
		.13	.15	.14		.7	.13
HAB	SITE	MALL	GOOS	BITT	YLEG	MUSK	RAIL
G	6		.14				
		HERO	DUCK	BEAV	COOT	PARU	PROT

THIS DATA SET CONTAINS:
0 NONFOREST WETLAND SAMPLE SITES
2 BOTTOMLAND HARDWOODS-WETLAND SAMPLE SITES
0 CROPLAND-WETLAND SAMPLE SITES
1 GRASSLAND-WETLAND SAMPLE SITES

AVERAGE HABITAT INDEXES BY HABITAT TYPE

HAB	MALL	GOOS	BITT	YLEG	MUSK	RAIL	HERO	DUCK	BEAV	COOT	PARU	PROT
N												
B	.85						.13	.15	.14		.73	.14
C												
G		.14										

TABLE K-7

PROJECT NAME: PEORIA LAKE HREP
BARRIER ISLAND CREATION
TARGET YEAR 00 EXISTING CONDITIONS

HAB	SITE	MALL	GOOS	BITT	YLEG	MUSK	RAIL
N	3	.12	.1	.54	.67	.81	.1
		HERO	DUCK	BEAV	COOT	PARU	PROT
		.79			.71		
HAB	SITE	MALL	GOOS	BITT	YLEG	MUSK	RAIL
N	4	.11	.1	.1	.72	.1	.1
		HERO	DUCK	BEAV	COOT	PARU	PROT
		.72			.1		

THIS DATA SET CONTAINS:
2 NONFOREST WETLAND SAMPLE SITES

AVERAGE HABITAT INDEXES BY HABITAT TYPE

HAB	MALL	GOOS	BITT	YLEG	MUSK	RAIL	HERO	DUCK	BEAV	COOT	PARU	PROT
N	.11	.1	.32	.69	.46	.1	.75			.41		
B												
C												
G		.14										

TABLE K-8

PROJECT NAME: PEORIA LAKE HREP
BARRIER ISLAND CREATION
TARGET YEAR 01 WITH PROJECT

SAMPLE SITE HABITAT INDEXES

HAB	SITE	MALL	GOOS	BITT	YLEG	MUSK	RAIL
N	3	.12	.1	.49	.62	.76	.1
		HERO	DUCK	BEAV	COOT	PARU	PROT
		.79			.66		
HAB	SITE	MALL	GOOS	BITT	YLEG	MUSK	RAIL
		HERO	DUCK	BEAV	COOT	PARU	PROT
HAB	SITE	MALL	GOOS	BITT	YLEG	MUSK	RAIL
G	6		.14				
		HERO	DUCK	BEAV	COOT	PARU	PROT

THIS DATA SET CONTAINS:
1 NONFOREST WETLAND SAMPLE SITES
0 BOTTOMLAND HARDWOODS-WETLAND SAMPLE SITES
0 CROPLAND-WETLAND SAMPLE SITES
1 GRASSLAND-WETLAND SAMPLE SITES

AVERAGE HABITAT INDEXES BY HABITAT TYPE

HAB	MALL	GOOS	BITT	YLEG	MUSK	RAIL	HERO	DUCK	BEAV	COOT	PARU	PROT
N	.12	.1	.49	.62	.76	.1	.79			.66		
B												
C												
G		.14										

TABLE K-9

PROJECT NAME: PEORIA LAKE HREP
BARRIER ISLAND CREATION
TARGET YEAR 25 WITH PROJECT

SAMPLE SITE HABITAT INDEXES

HAB	SITE	MALL	GOOS	BITT	YLEG	MUSK	RAIL
N	3	.45	.1	.69	.48	.81	.46
		HERO	DUCK	BEAV	COOT	PARU	PROT
		.73			.81		
HAB	SITE	MALL	GOOS	BITT	YLEG	MUSK	RAIL
B	5	.34					
		HERO	DUCK	BEAV	COOT	PARU	PROT
		.59	.55	.52		.5	.58
HAB	SITE	MALL	GOOS	BITT	YLEG	MUSK	RAIL
G	6		.14				
		HERO	DUCK	BEAV	COOT	PARU	PROT

THIS DATA SET CONTAINS:
1 NONFOREST WETLAND SAMPLE SITES
1 BOTTOMLAND HARDWOODS-WETLAND SAMPLE SITES
0 CROPLAND-WETLAND SAMPLE SITES
1 GRASSLAND-WETLAND SAMPLE SITES

AVERAGE HABITAT INDEXES BY HABITAT TYPE

HAB	MALL	GOOS	BITT	YLEG	MUSK	RAIL	HERO	DUCK	BEAV	COOT	PARU	PROT
N	.45	.1	.69	.48	.81	.46	.73			.81		
B	.34						.59	.55	.52		.5	.58
C												
G		.14										

TABLE K-10

PROJECT NAME: PEORIA LAKE HREP
BARRIER ISLAND CREATION
TARGET YEAR 50 WITH PROJECT

SAMPLE SITE HABITAT INDEXES

HAB	SITE						
		MALL	GOOS	BITT	YLEG	MUSK	RAIL
N	3	.65	.1	.67	.1	.81	.46
		HERO	DUCK	BEAV	COOT	PARU	PROT
		.72			.85		
HAB	SITE	MALL	GOOS	BITT	YLEG	MUSK	RAIL
B	5	.34					
		HERO	DUCK	BEAV	COOT	PARU	PROT
		.59	.55	.52		.5	.58
HAB	SITE	MALL	GOOS	BITT	YLEG	MUSK	RAIL
G	6		.14				
		HERO	DUCK	BEAV	COOT	PARU	PROT

THIS DATA SET CONTAINS:
1 NONFOREST WETLAND SAMPLE SITES
1 BOTTOMLAND HARDWOODS-WETLAND SAMPLE SITES
0 CROPLAND-WETLAND SAMPLE SITES
1 GRASSLAND-WETLAND SAMPLE SITES

AVERAGE HABITAT INDEXES BY HABITAT TYPE

HAB	MALL	GOOS	BITT	YLEG	MUSK	RAIL	HERO	DUCK	BEAV	COOT	PARU	PROT
N	.65	.1	.67	.1	.81	.46	.72			.85		
B	.34						.59	.55	.52		.5	.58
C												
G		.14										

HABITAT INVENTORIES

A

P

P

E

N

D

I

X

L

UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
DEFINITE PROJECT REPORT
WITH INTEGRATED ENVIRONMENTAL ASSESSMENT (R-6F)

PEORIA LAKE ENHANCEMENT
PEORIA POOL, ILLINOIS WATERWAY, RIVER MILES 178.5 TO 181

APPENDIX L
HABITAT INVENTORIES

TABLE OF CONTENTS

List of Tables

TABLE L-1. Fisheries Data Collected 1984-1989 within the Project Boundaries of Goose Lake, East River Channel and the Illinois River. (Table indicates the species collected and the years it was collected.)

Species	Year					
	84	85	86	87	88	89
SHORTNOSE GAR						X
SKIPJACK HERRING	X		X	X		
GIZZARD SHAD	X		X	X	X	X
GOLDFISH		X	X			X
CARPXGOLDFISH		X	X		X	
CARP	X	X	X	X	X	X
SILVER CHUB			X			
EMERALD SHINER	X	X	X	X	X	X
STRIPED SHINER				X		
RIVER SHINER	X					
SPOTTAIL SHINER	X	X			X	X
FATHEAD MINNOW						X
BULLHEAD MINNOW	X		X		X	X
RIVER CARPSUCKER	X	X	X	X	X	X
QUILLBACK	X		X		X	X
WHITE SUCKER			X			
SMALLMOUTH BUFFALO	X	X		X	X	X
BIGMOUTH BUFFALO	X			X		
BLACK BUFFALO	X					
GOLDEN REDHORSE				X		
SHORTHEAD REDHORSE		X		X		X
BLACK BULLHEAD					X	
YELLOW BULLHEAD		X	X			
CHANNEL CATFISH	X	X	X	X	X	X
STARHEAD TOPMINNOW						X
WHITE BASS	X	X	X	X	X	X
YELLOW BASS					X	X
GREEN SUNFISH	X	X	X		X	X
ORANGESPOT SUNFISH			X	X	X	X
BLUEGILL	X	X	X		X	X
SMALLMOUTH BASS		X				X
LARGEMOUTH BASS	X	X	X	X	X	X
WHITE CRAPPIE	X	X	X	X		
BLACK CRAPPIE	X	X		X	X	
BLACKSIDE DARTER					X	
LOGPERCH						X
SAUGER	X	X				X
WALLEYE	X		X			
FRESHWATER DRUM	X	X	X	X	X	X

TABLE L-2. Waterfowl Census Information.

LOCATION: RICE POND

Year	Day	Dabblers	Day	Divers
1979	10/30	53,150	11/7	2,070
1980	10/20	38,675	11/3	1,835
1981	10/26	34,980	11/17	660
1982	11/4	19,300	12/6	625
1983	11/1	25,375	10/25	610
1984	10/29	18,800	10/29	1,030
1985	10/28	48,910	11/4	3,375
1986	11/3	28,800	11/3	1,645
1987	11/17	44,150	11/2	1,900
1988	11/14	36,775	11/14	1,120

LOCATION: GOOSE POND

Year	Day	Dabblers	Day	Divers
1979	12/5	118,200	11/7	1,890
1980	12/11	32,600	11/3	630
1981	11/17	41,300	11/17	2,115
1982	12/6	9,675	11/8	690
1983	11/21	33,000	11/8	955
1984	11/12	11,350	11/12	715
1985	11/4	6,980	11/4	2,365
1986	11/10	2,540	11/10	965
1987	11/23	3,625	11/23	1,075
1988	12/5	3,580	11/21	655

LOCATION: UPPER PEORIA LAKE

Year	Day	Dabblers	Day	Divers
1979	12/5	26,400	11/7	13,025
1980	12/11	20,550	11/10	1,840
1981	11/3	49,900	11/17	2,825
1982	11/15	34,700	11/8	1,855
1983	12/8	14,250	11/8	1,720
1984	11/26	18,250	11/5	2,560
1985	11/4	20,890	11/4	8,850
1986	11/10	20,450	11/3	4,665
1987	12/2	46,100	11/23	6,400
1988	11/28	40,800	11/21	5,950

Waterfowl numbers represent one-day peak numbers for that year.

State Natural History Survey Division

Room 99
Natural Resources Building
607 East Peabody Drive
Champaign, IL 61820
217/333-6880

ENR
Illinois Department of
Energy and Natural Resources

17 March, 1989

Dear Mr. Slater:

Enclosed please find a compilation of data which will hopefully satisfy your data request.

-List of threatened or endangered species found in Peoria, Woodford, Marshall and Stark counties

-List of species associated with wetlands (these species have been collected in the four county area or sighted there)

-List of mussels and fish collected from four county area and indication of which are threatened or endangered.

If you need any more information or have any questions please contact me at the Survey address given above or call (217) 384-0161.

Sincerely,

Pamela Pescitelli

Pamela Pescitelli
IFWIS Database Manager

TABLE L-3. Threatened and Endangered Species List for the Four-County Area (Peoria, Woodford, Marshall, and Stark)

SPECIES	FEDERAL END	FEDERAL THR	FEDERAL PROP	CAND	STATE END	STATE THR	STATE PROP	/WATCH
*MOLLUSK (PELECY)								
ALASMIDONTA VIRIDIS	0	0	0	0	0	0		1
SLIPPERSHELL								
LASMIGONA COMPRESSA	0	0	0	0	0	0		1
CREEK HEELSPLITTER								
ACTINONAIAS ELLIPSIFORMIS	0	0	0	0	0	0		1
ELLIPSE								
TOTAL MOLLUSK (PELECY) 3								
*REPTILES								
MACROCLEMYS TEMMINCKI	0	0	0	1	0	0		0
ALLIGATOR SNAPPING TURTLE								
KINOSTERNON FLAVESCENS SPOONERI	0	0	0	1	1	0		0
ILLINOIS MUD TURTLE								
EMYDOIDEA BLANDINGI	0	0	0	0	0	0		1
BLANDING'S TURTLE								
SISTRURUS CATENATUS CATENATUS	0	0	0	1	0	0		0
EASTERN MASSASAUGA								
TOTAL REPTILES 4								
*BIRDS								
PODILYMBUS PODICEPS	0	0	0	0	0	0		1
PIED-BILLED GREBE								
PHALACROCORAX AURITUS	0	0	0	0	1	0		0
DOUBLE-CRESTED CORMORANT								
BOTAURUS LENTIGINOSUS	0	0	0	0	1	0		0
AMERICAN BITTERN								
CASMERODIUS ALBUS	0	0	0	0	1	0		0
GREAT EGRET								
EGRETTA THULA	0	0	0	0	1	0		0
SNOWY EGRET								
EGRETTA CAERULEA	0	0	0	0	1	0		0
LITTLE BLUE HERON								
NYCTICORAX NYCTICORAX	0	0	0	0	1	0		0
BLACK-CROWNED NIGHT-HERON								
PANDION HALIAETUS	0	0	0	0	1	0		0
OSPREY								
HALIAEETUS LEUCOCEPHALUS	1	0	0	0	1	0		0
BALD EAGLE								
ACCIPITER COOPERII	0	0	0	0	1	0		0
COOPER'S HAWK								
CERTHIA AMERICANA	0	0	0	0	1	0		0
BROWN CREEPER								
CATHARUS FUSCESCENS	0	0	0	0	0	1		0
VEERY								
TOTAL BIRDS 12								
*MAMMALS								
MUSTELA FRENATA	0	0	0	0	0	0		1
LONG-TAILED WEASEL								
LUTRA CANADENSIS	0	0	0	0	0	1		0
RIVER OTTER								

TABLE L-4. List of Species Found in the Four-County Area Which Are Associated With Wetlands.

*AMBLEMA PLICATA	THREE-RIDGE
*FUSCONAIA FLAVA	WABASH PIGTOE
*QUADRULA PUSTULOSA	PIMPLEBACK
*QUADRULA QUADRULA	MAPLELEAF
*TRITOGONIA VERRUCOSA	BUCKHORN
*ALASMIDONTA VIRIDIS	SLIPPERSHELL
*ALASMIDONTA MARGINATA	ELKTOE
*ANODONTA IMBECILLIS	PAPER PONDSHELL
*ANODONTOIDES FERUSSACIANUS	CYLINDRICAL PAPERSHELL
*LASMIGONA COMPLANATA	WHITE HEELSPLITTER
*LASMIGONA COMPRESSA	CREEK HEELSPLITTER
*LASMIGONA COSTATA	FLUTED SHELL
*STROPHITUS UNDULATUS	SQUAWFOOT
*ACTINONAIAS ELLIPSIFORMIS	ELLIPSE
*LEPTODEA FRAGILIS	FRAGILE PAPERSHELL
*POTAMILUS ALATUS	PINK HEELSPLITTER
*TOXOLASMA PARVUS	LILLIPUT
*CAECIDOTEA INTERMEDIUS	ISOPOD
*CAECIDOTEA KENDEIGHI	ISOPOD
*HYALELLA AZTECA	AMPHIPOD
*BACTRURUS MUCRONATUS	AMPHIPOD
*CRANGONYX GRACILIS	AMPHIPOD
*PROCAMBARUS ACUTUS	CRAYFISH
*PROCAMBARUS GRACILIS	CRAYFISH
*ORCONECTES IMMUNIS	CRAYFISH
*ORCONECTES PROPINQUUS	CRAYFISH
*ORCONECTES VIRILIS	CRAYFISH
*CAMBARUS DIOGENES	CRAYFISH
*ICHTHYOMYZON CASTANEUS	CHESTNUT LAMPREY
*ICHTHYOMYZON UNICUSPIS	SILVER LAMPREY
*POLYODON SPATHULA	PADDLEFISH
*LEPISOSTEUS OSSEUS	LONGNOSE GAR
*LEPISOSTEUS PLATOSTOMUS	SHORTNOSE GAR
*AMIA CALVA	BOWFIN
*ANGUILLA ROSTRATA	AMERICAN EEL
*ALOSA CHRYSOCHLORIS	SKIPJACK HERRING
*DOROSOMA CEPEDIANUM	GIZZARD SHAD
*HIODON ALOSOIDES	GOLDEYE
*UMBRA LIMI	CENTRAL MUDMINNOW
*ESOX LUCIUS	NORTHERN PIKE
*CAMPOSTOMA ANOMALUM	CENTRAL STONEROLLER
*CARASSIUS AURATUS	GOLDFISH
*CYPRINUS CARPIO	COMMON CARP
*HYBOGNATHUS NUCHALIS	MISSISSIPPI SILVERY MINNO
*HYBOPSIS STORERIANA	SILVER CHUB
*NOCOMIS BIGUTTATUS	HORNYHEAD CHUB
*NOTEMIGONUS CRYSOLEUCAS	GOLDEN SHINER
*NOTROPIS ATHERINOIDES	EMERALD SHINER
*NOTROPIS BLENNIUS	RIVER SHINER
*NOTROPIS BUCHANANI	GHOST SHINER
*NOTROPIS CHRYSOCEPHALUS	STRIPED SHINER
*NOTROPIS DORSALIS	BIGMOUTH SHINER
*NOTROPIS EMILIAE	PUGNOSE MINNOW

*NOTROPIS LUTRENSIS	RED SHINER
*NOTROPIS RUBELLUS	ROSYFACE SHINER
*NOTROPIS STRAMINEUS	SAND SHINER
*NOTROPIS UMBRATILIS	REDFIN SHINER
*PHENACOBIUS MIRABILIS	SUCKERMOUTH MINNOW
*PHOXINUS ERYTHROGASTER	SOUTHERN REDBELLY DACE
*PIMEPHALES NOTATUS	BLUNTNOSE MINNOW
*PIMEPHALES PROMELAS	FATHEAD MINNOW
*PIMEPHALES VIGILAX	BULLHEAD MINNOW
*RHINICHTHYS ATRATULUS	BLACKNOSE DACE
	CREEK CHUB
CARPIODES CARPIO	
*CARPIODES CYPRINUS	QUILLBACK
*CARPIODES VELIFER	HIGHFIN CARPSUCKER
*CATOSTOMUS COMMERSONI	WHITE SUCKER
ERIMYZON OBLONGUS	CREEK CHUBSUCKER
*HYPENTELIUM NIGRICANS	NORTHERN HOG SUCKER
*ICTIOBUS BUBALUS	SMALLMOUTH BUFFALO
*ICTIOBUS CYPRINELLUS	BIGMOUTH BUFFALO
*ICTIOBUS NIGER	BLACK BUFFALO
*MOXOSTOMA ANISURUM	SILVER REDHORSE
*MOXOSTOMA DUQUESNEI	BLACK REDHORSE
*MOXOSTOMA ERYTHRURUM	GOLDEN REDHORSE
*MOXOSTOMA MACROLEPIDOTUM	SHORTHEAD REDHORSE
*ICTALURUS CATUS	WHITE CATFISH
*ICTALURUS MELAS	BLACK BULLHEAD
*ICTALURUS NATALIS	YELLOW BULLHEAD
*ICTALURUS NEBULOSUS	BROWN BULLHEAD
*ICTALURUS PUNCTATUS	CHANNEL CATFISH
*NOTURUS FLAVUS	STONECAT
*NOTURUS GYRINUS	TADPOLE MADTOM
*NOTURUS NOCTURNUS	FRECKLED MADTOM
*PERCOPSIS OMISCOMAYCUS	TROUT-PERCH
*FUNDULUS NOTATUS	BLACKSTRIPE TOPMINNOW
*GAMBUSIA AFFINIS	MOSQUITOFISH
*LABIDESTHES SICCULUS	BROOK SILVERSIDE
*MORONE CHRYSOPS	WHITE BASS
*MORONE MISSISSIPPIENSIS	YELLOW BASS
*AMBLOPLITES RUPESTRIS	ROCK BASS
*LEPOMIS CYANELLUS	GREEN SUNFISH
*LEPOMIS GIBBOSUS	PUMPKINSEED
*LEPOMIS GULOSUS	WARMOUTH
*LEPOMIS HUMILIS	ORANGESPOTTED SUNFISH
*LEPOMIS MACROCHIRUS	BLUEGILL
*LEPOMIS MEGALOTIS	LONGEAR SUNFISH
*MICROPTERUS DOLOMIEUI	SMALLMOUTH BASS
*MICROPTERUS SALMOIDES	LARGEMOUTH BASS
*POMOXIS ANNULARIS	WHITE CRAPPIE
*POMOXIS NIGROMACULATUS	BLACK CRAPPIE
*ETHEOSTOMA ASPRIGENE	MUD DARTER
*ETHEOSTOMA CHLOROSOMUM	BLUNTNOSE DARTER
*ETHEOSTOMA FLABELLARE	FANTAIL DARTER
*ETHEOSTOMA NIGRUM	JOHNNY DARTER
*ETHEOSTOMA SPECTABILE	ORANGETHROAT DARTER
*ETHEOSTOMA ZONALE	BANDED DARTER
*PERCA FLAVESCENS	YELLOW PERCH
*PERCINA CAPRODES	LOGPERCH
*PERCINA MACULATA	BLACKSIDE DARTER
*STIZOSTEDION CANADENSE	SAUGER
*STIZOSTEDION VITREUM	WALLEYE
*APLODINOTUS GRUNNIENS	FRESHWATER DRUM
*NECTURUS MACULOSUS MACULOSUS	MUD PUPPY
*AMBYSTOMA TIGRINUM TIGRINUM	EASTERN TIGER SALAMANDER
*NOTOPHTHALMUS VIRIDESCENS LOUISIANENSIS	CENTRAL NEWT
*BUFO WOODHOUSEI FOWLERI	FOWLER'S TOAD

TABLE L-4 (Cont'd)

*ACRIS CREPITANS BLANCHARDI	BLANCHARD'S CRICKET FROG
*HYLA VERSICOLOR	GRAY TREEFROG
*HYLA CRUCIFER CRUCIFER	NORTHERN SPRING PEEPER
*RANA BLAIRI	PLAINS LEOPARD FROG
*RANA CATESBEIANA	BULLFROG
*RANA PIPIENS	NORTHERN LEOPARD FROG
*RANA SYLVATICA	WOOD FROG
*CHELYDRA SERPENTINA SERPENTINA	COMMON SNAPPING TURTLE
*MACROCLEMYS TEMMINCKI	ALLIGATOR SNAPPING TURTLE
*STERNOTHERUS ODORATUS	STINKPOT
*KINOSTERNON FLAVESCENS	ILLINOIS MUD TURTLE
KINOSTERNON SUBRUBRUM	EASTERN MUD TURTLE
*EMYDOIDEA BLANDINGI	BLANDING'S TURTLE
*PSEUDEMYS SCRIPTA ELEGANS	POND SLIDER
*GRAPTEMYS GEOGRAPHICA	MAP TURTLE
*TRIONYX MUTICUS MUTICUS	MIDLAND SMOOTH SOFTSHELL
*TRIONYX SPINIFERUS SPINIFERUS	EASTERN SPINY SOFTSHELL
*LAMPROPELTIS TRIANGULUM TRIANGULUM	EASTERN MILK SNAKE
*NERODIA RHOMBIFERA RHOMBIFERA	DIAMONDBACK WATER SNAKE
*NERODIA ERYTHROGASTER FLAVIGASTER	YELLOWBELLY WATER SNAKE
*NERODIA SIPEDON SIPEDON	NORTHERN WATER SNAKE
*REGINA SEPTEMVITTATA	QUEEN SNAKE
*THAMNOPHIS PROXIMUS PROXIMUS	WESTERN RIBBON SNAKE
*SISTRURUS CATENATUS CATENATUS	EASTERN MASSASAUGA
*PODILYMBUS PODICEPS	PIED-BILLED GREBE
*PHALACROCORAX AURITUS	DOUBLE-CRESTED CORMORANT
*BOTAURUS LENTIGINOSUS	AMERICAN BITTERN
*ARDEA HERODIAS	GREAT BLUE HERON
*CASMERODIUS ALBUS	GREAT EGRET
*EGRETTA THULA	SNOWY EGRET
*EGRETTA CAERULEA	LITTLE BLUE HERON
*BUBULCUS IBIS	CATTLE EGRET
*BUTORIDES STRIATUS	GREEN-BACKED HERON
*NYCTICORAX NYCTICORAX	BLACK-CROWNED NIGHT-HERON
*NYCTICORAX VIOLACEUS	YELLOW-CROWNED NIGHT-HERO
*AIX SPONSA	WOOD DUCK
*LOPHODYTES CUCULLATUS	HOODED MERGANSER
*CORAGYPS ATRATUS	BLACK VULTURE
*PANDION HALIAETUS	OSPREY
*HALIAEETUS LEUCOCEPHALUS	BALD EAGLE
*BUTEO PLATYPTERUS	BROAD-WINGED HAWK
*BUTEO JAMAICENSIS	RED-TAILED HAWK
*RALLUS ELEGANS	KING RAIL
*RALLUS LIMICOLA	VIRGINIA RAIL
*PORZANA CAROLINA	SORA
*ACTITIS MACULARIA	SPOTTED SANDPIPER
*SCOLOPAX MINOR	AMERICAN WOODCOCK
*LARUS DELAWARENSIS	RING-BILLED GULL
*STERNA CASPIA	CASPIAN TERN
*BUBO VIRGINIANUS	GREAT HORNED OWL
*STRIX VARIA	BARRED OWL
*EMPIDONAX VIRESCENS	ACADIAN FLYCATCHER
*EMPIDONAX TRAILLII	WILLOW FLYCATCHER
*EMPIDONAX MINIMUS	LEAST FLYCATCHER
*TACHYCINETA BICOLOR	TREE SWALLOW
*RIPARIA RIPARIA	BANK SWALLOW
*CERTHIA AMERICANA	BROWN CREEPER
*POLIOPTILA CAERULEA	BLUE-GRAY GNATCATCHER
*CATHARUS FUSCESCENS	VEERY
*VIREO GRISEUS	WHITE-EYED VIREO
*VIREO GILVUS	WARBLING VIREO
*VERMIVORA PINUS	BLUE-WINGED WARBLER
*DENDROICA PETECHIA	YELLOW WARBLER
*DENDROICA DOMINICA	YELLOW-THROATED WARBLER
*SETOPHAGA RUTICILLA	AMERICAN REDSTART

TABLE L-4 (Cont'd)

*WILSONIA CITRINA	HOODED WARBLER
*SPIZELLA PUSILLA	FIELD SPARROW
*DOLICHONYX ORYZIVORUS	BOBOLINK
*ICTERUS SPURIUS	ORCHARD ORIOLE
*BLARINA BREVICAUDA	NORTHERN SHORT-TAILED SHREW
*CRYPTOTIS PARVA	LEAST SHREW
*MYOTIS LUCIFUGUS	LITTLE BROWN BAT
*MYOTIS KEENII	KEEN'S BAT
*EPTESICUS FUSCUS	BIG BROWN BAT
*LASIURUS BOREALIS	RED BAT
*LASIURUS CINEREUS	HOARY BAT
SPERMOPHILUS FRANKLINII	FRANKLIN'S GROUND SQUIRREL
*REITHRODONTOMYS MEGALOTIS	WESTERN HARVEST MOUSE
*PEROMYSCUS LEUCOPUS	WHITE-FOOTED MOUSE
*MICROTUS PENNSYLVANICUS	MEADOW VOLE
*ONDATRA ZIBETHICUS	MUSKRAT
*SYNAPTOMYS COOPERI	SOUTHERN BOG LEMMING
*CANIS LATRANS	COYOTE
*VULPES VULPES	RED FOX
*UROCYON CINEREOARGENTEUS	GRAY FOX
*MUSTELA NIVALIS	LEAST WEASEL
*MUSTELA FRENATA	LONG-TAILED WEASEL
*LUTRA CANADENSIS	RIVER OTTER

209 SPECIES

TABLE L-5. Mussel and Fish Species Collected in the Four-County Area.

Table L-5

Mussel and fish species collected in the four county area.

*AMBLEMA PLICATA	THREE-RIDGE
*FUSCONAIA FLAVA	WABASH PIGTOE
*QUADRULA PUSTULOSA	PIMPLEBACK
*QUADRULA QUADRULA	MAPLELEAF
*TRITOGONIA VERRUCOSA	BUCKHORN
*PLEUROBEMA CORDATUM	OHIO RIVER PIGTOE
*ALASMIDONTA VIRIDIS	SLIPPERSHELL
*ALASMIDONTA MARGINATA	ELKTOE
*ANODONTA GRANDIS	COMMON FLOATER
*ANODONTA GRANDIS GRANDIS	COMMON FLOATER
*ANODONTA GRANDIS CORPULENTA	STOUT FLOATER
*ANODONTA IMBECILLIS	PAPER PONDSHELL
*ANODONTOIDES FERUSSACIANUS	CYLINDRICAL PAPERSHELL
*LASMIGONA COMPLANATA	WHITE HEELSPLITTER
*LASMIGONA COMPRESSA	CREEK HEELSPLITTER
*LASMIGONA COSTATA	FLUTED SHELL
*STROPHITUS UNDULATUS	SQUAWFOOT
*ACTINONAIAS ELLIPSIFORMIS	ELLIPSE
*LAMPSILIS SILIQUOIDEA	FATMUCKET
*LAMPSILIS TERES	YELLOW SANDSHELL
*LAMPSILIS VENTRICOSA	PLAIN POCKETBOOK
*LEPTODEA FRAGILIS	FRAGILE PAPERSHELL
*POTAMILUS ALATUS	PINK HEELSPLITTER
*POTAMILUS LAEVISSIMA	PINK PAPER SHELL
*TOXOLASMA PARVUS	LILLIPUT
*ICHTHYOMYZON CASTANEUS	CHESTNUT LAMPREY
*ICHTHYOMYZON UNICUSPIS	SILVER LAMPREY
*POLYODON SPATHULA	PADDLEFISH
*LEPISOSTEUS OSSEUS	LONGNOSE GAR
*LEPISOSTEUS PLATOSTOMUS	SHORTNOSE GAR
*AMIA CALVA	BOWFIN
*ANGUILLA ROSTRATA	AMERICAN EEL
*ALOSA CHRYSOCHLORIS	SKIPJACK HERRING
*DOROSOMA CEPEDIANUM	GIZZARD SHAD
*HIODON ALOSOIDES	GOLDEYE
*UMBRA LIMI	CENTRAL MUDMINNOW
*ESOX LUCIUS	NORTHERN PIKE
*CAMPOSTOMA ANOMALUM	CENTRAL STONEROLLER
*CARASSIUS AURATUS	GOLDFISH
*CYPRINUS CARPIO	COMMON CARP
*HYBOGNATHUS NUCHALIS	MISSISSIPPI SILVERY MINNO
*HYBOPSIS STORERIANA	SILVER CHUB
*NOCOMIS BIGUTTATUS	HORNYHEAD CHUB
*NOTEMIGONUS CRYSOLEUCAS	GOLDEN SHINER
*NOTROPIS	
*NOTROPIS ATHERINOIDES	EMERALD SHINER
*NOTROPIS BLENNIUS	RIVER SHINER
*NOTROPIS BUCHANANI	GHOST SHINER
*NOTROPIS CHRYSOCEPHALUS	STRIPED SHINER
*NOTROPIS DORSALIS	BIGMOUTH SHINER
*NOTROPIS EMILIAE	PUGNOSE MINNOW
*NOTROPIS HUDSONIUS	SPOTTAIL SHINER

TABLE L-5 (Cont'd)

*NOTROPIS RUBELLUS	ROSYFACE SHINER
*NOTROPIS STRAMINEUS	SAND SHINER
*NOTROPIS UMBRATILIS	REDFIN SHINER
*NOTROPIS CHRYSOCEPHALUS HYBRID	
*PHENACOBIUS MIRABILIS	SUCKERMOUTH MINNOW
*PHOXINUS ERYTHROGASTER	SOUTHERN REDBELLY DACE
*PIMEPHALES NOTATUS	BLUNTNOSE MINNOW
*PIMEPHALES PROMELAS	FATHEAD MINNOW
*PIMEPHALES VIGILAX	BULLHEAD MINNOW
*RHINICHTHYS ATRATULUS	BLACKNOSE DACE
*SEMOTILUS ATROMACULATUS	CREEK CHUB
CARPIODES CARPIO	RIVER CARPSUCKER
*CARPIODES CYPRINUS	QUILLBACK
*CARPIODES VELIFER	HIGHFIN CARPSUCKER
*CATOSTOMUS COMMERSONI	WHITE SUCKER
*ERIMYZON OBLONGUS	CREEK CHUBSUCKER
*HYPENTELIUM NIGRICANS	NORTHERN HOG SUCKER
*ICTIOBUS	
*ICTIOBUS BUBALUS	SMALLMOUTH BUFFALO
*ICTIOBUS CYPRINELLUS	BIGMOUTH BUFFALO
*ICTIOBUS NIGER	BLACK BUFFALO
*MOXOSTOMA ANISURUM	SILVER REDHORSE
*MOXOSTOMA DUQUESNEI	BLACK REDHORSE
*MOXOSTOMA ERYTHRURUM	GOLDEN REDHORSE
*MOXOSTOMA MACROLEPIDOTUM	SHORTHEAD REDHORSE
*ICTALURUS CATUS	WHITE CATFISH
*ICTALURUS MELAS	BLACK BULLHEAD
*ICTALURUS NATALIS	YELLOW BULLHEAD
*ICTALURUS NEBULOSUS	BROWN BULLHEAD
*ICTALURUS PUNCTATUS	CHANNEL CATFISH
*NOTURUS FLAVUS	STONECAT
*NOTURUS GYRINUS	TADPOLE MADTOM
*NOTURUS NOCTURNUS	FRECKLED MADTOM
*PERCOPSIS OMISCOMAYCUS	TROUT-PERCH
*FUNDULUS NOTATUS	BLACKSTRIPE TOPMINNOW
*GAMBUSIA AFFINIS	MOSQUITOFISH
*LABIDESTHES SICCULUS	BROOK SILVERSIDE
*MORONE CHRYSOPS	WHITE BASS
*MORONE MISSISSIPPIENSIS	YELLOW BASS
*AMBLOPLITES RUPESTRIS	ROCK BASS
*LEPOMIS CYANELLUS	GREEN SUNFISH
*LEPOMIS GIBBOSUS	PUMPKINSEED
*LEPOMIS GULOSUS	WARMOUTH
*LEPOMIS HUMILIS	ORANGESPOTTED SUNFISH
*LEPOMIS MACROCHIRUS	BLUEGILL
*LEPOMIS MEGALOTIS	LONGEAR SUNFISH
*MICROPTERUS DOLOMIEUI	SMALLMOUTH BASS
*MICROPTERUS SALMOIDES	LARGEMOUTH BASS
*POMOXIS ANNULARIS	WHITE CRAPPIE
*POMOXIS NIGROMACULATUS	BLACK CRAPPIE
*ETHEOSTOMA ASPRIGENE	MUD DARTER
*ETHEOSTOMA CHLOROSOMUM	BLUNTNOSE DARTER
*ETHEOSTOMA FLABELLARE	FANTAIL DARTER
*ETHEOSTOMA NIGRUM	JOHNNY DARTER
*ETHEOSTOMA SPECTABILE	ORANGETHROAT DARTER
*ETHEOSTOMA ZONALE	BANDED DARTER
*PERCA FLAVESCENS	YELLOW PERCH
*PERCINA CAPRODES	LOGPERCH
*PERCINA MACULATA	BLACKSIDE DARTER
*PERCINA PHOXOCEPHALA	SLENDERHEAD DARTER
*STIZOSTEDION CANADENSE	SAUGER
*STIZOSTEDION VITREUM	WALLEYE
*APLODINOTUS GRUNNIENS	FRESHWATER DRUM

116 SPECIES

TABLE L-6. Peoria Lake Field Data

Inter-Agency Field Trip on July 5, 1989
TIME: 10:15-1200 hours
WEATHER: clear, sunny, and 80-90 degrees F.

CURSORY MUSSEL SURVEY FOR PEORIA LAKE

ROME POINT AREA: Random sampling of the Rome point area in the vicinity of an old commercial mussel bed. Mussels were located in a sporadic distribution. The following species were collected:

Three-ridge (*Amblema plicata*)
Maple leaf (*Quadrula quadrula*)
Fragile papershell (*Leptodea fragilis*)
White heelsplitter (*Lasimigona complanata*)
Giant floater (*Anodanta grandis*)

The area was dominated by three-ridge and maple leaf species.

EAST RIVER CHANNEL: A total of 6 crowfoot brail runs were made in the East River channel. A total of 2 mussels, one three-ridge (*Amblema plicata*) and one maple leaf (*Quadrula quadrula*), were recovered.

PONAR GRAB SAMPLES FOR PEORIA LAKE AND THE EAST RIVER CHANNEL: In addition to the mussel survey, 20 ponar grab samples were taken throughout the project area, including the East River channel, Goose Lake and Peoria Lake proper. Analysis of benthic organism composition has not been completed to date. Field observations indicated that the benthic community is extremely limited in the project area.

STRUCTURAL CONSIDERATIONS

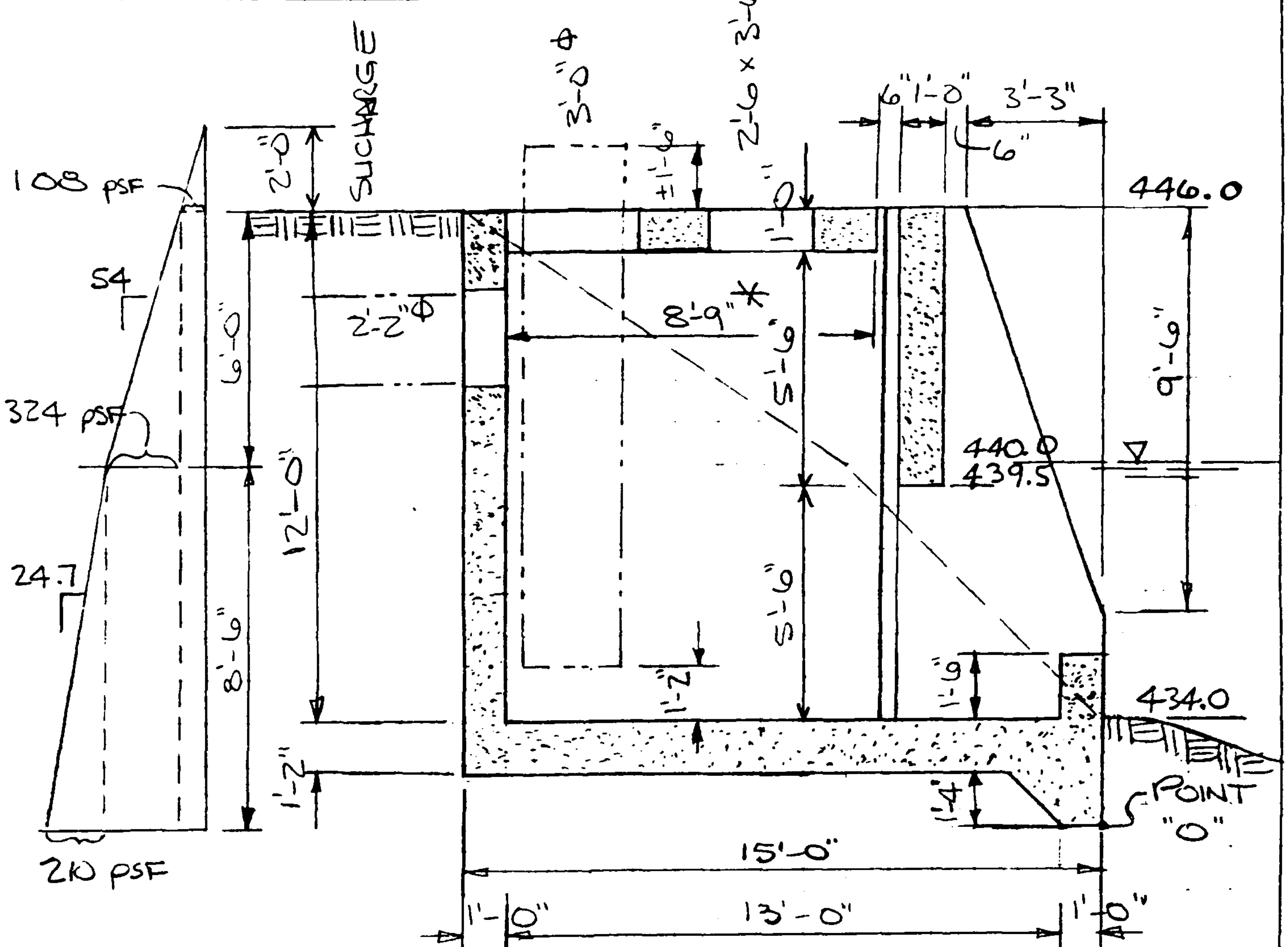
A
P
P
E
N
D
I
X

M

Subject PEORIA LAKE - PUMP STATION		Date 10 APR. 90
Computed by K. WILSON	Checked by DAP	Sheet PS1 of

REV. 20 APR. 90

STABILITY



BACKFILL MATERIAL

$\gamma_{SAT.} = 115$ PCF

$c = 0$

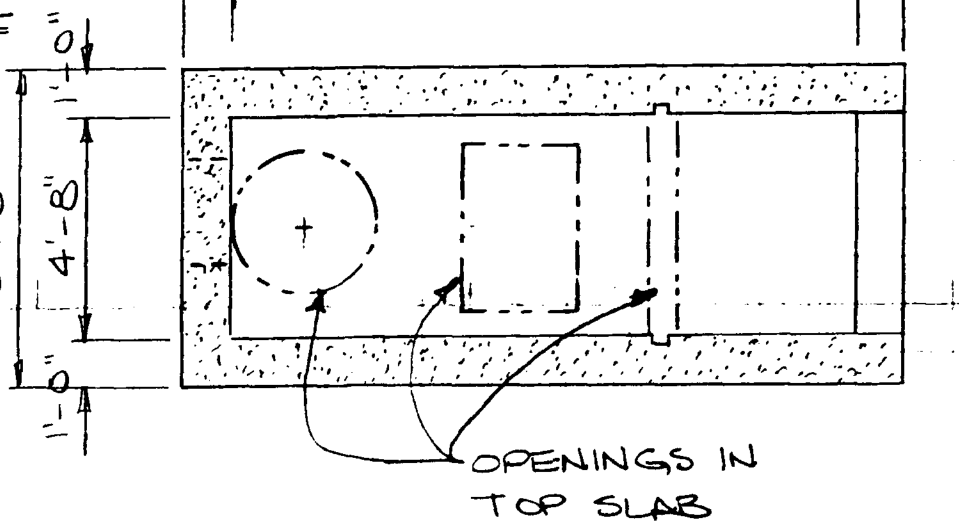
$\phi = 32°$

$K_o = 1 - \sin\phi$

$= 0.470$

$P_o = 115\,(0.470)$

$= 54$ PSF/FT.



NCR Form 381b
1 Aug 80

Subject PEORIA LAKE - PUMP STATION		Date 10 APR. 90
Computed by K. WILSON	Checked by DAP	Sheet PS2 of

REV. 20 APR. 90

STABILITY

UNIT	FORCE	ARM	MOMENT
BACK WALL 150 (4.667)(12.000)	8,400#	-14.500	-121,800 FT-#
$-150(\pi)(1.083)^2$	- 552	-14.500	8,004
FRONT WALL 150 (4,667)(6.500)	4,550	-4.250	-19,338
WIER WALL 150 (4,667)(1.500)	1,050	-0.500	-525
APRON 150 (6.667)(1.333)	1,333	-0.500	-667
$150(6.667)\left(\frac{1.333}{2}\right)^2$	888	-1.444	-1,282
SIDE WALLS 150(15.000)(12.000)2	54,000	-7.500	-405,000
$-150(3.250)\left(\frac{9.500}{2}\right)2$	- 4,631	-1.083	5,015
BASE SLAB 150(1.167)(6.667)(15.000)	17,506	-7.500	-131,295
TOP SLAB 150 (4.667)(8.750)	6,125	-9.625	-58,953
-150 (2.500)(3.500)	-1,313	-8.000	10,504
$-150(\pi)(1.500)^2$	-1,060	-12.500	13,250
TOTAL CONC. WT.	86,296#	-8.1358	-702,087 FT-#
PUMP PIPE 10.2(π)(2.3125)(12.333)	914#	-12.500	-11,425 FT#
WATER W/O STOP LOGS IN PLACE (VERT) 62.4(6.0)(4.667)(14.00)	24,463#	-7.000	-171,241 FT#
WATER W/ STOP LOGS IN PLACE (VERT) 62.4(6.0)(4.667)(5.00)	8,737#	-2.500	-21,843 FT#
UPLIFT (ASSUMED UNIFORM) 62.4 (7.167)(6.667)(15.00)	-44,724#	-7.500	335,430 FT-#
PUMP IN PLACE (MANUF DATA)	2870#	-12.500	-35,875 FT-#
WATER COLUMN $62.4(\pi)\frac{(2.292)^2}{4}(3.483)$	897#	-12.500	-11,213 FT-#

NCR Form 1 Aug 80 381b

Subject PEORIA LAKE - PUMP STATION		Date 11 APR. 90
Computed by K. WILSON	Checked by DAP	Sheet PS3 of

REV. 20 APR. 90

STABILITY

UNIT	FORCE	ARM	MOMENT
EARTH PRESSURES	#		FT#
108 (6.667)(14.500) →	10,441	7.250	75,697
324 (6.667)(8.500) →	18,361	4.250	78,034
324 (6.667)(6.000)/2 →	6,480	10.500	68,043
210 (6.667)(8.500)/2 →	5,950	2.833	16,856
	41,232#		238,630 FT#
(NO PASSIVE PRESSURE ASSUMED)			
WATER PRESSURES BALANCE	—	—	—

SUMMATION

CASE #1 - STOP LOGS IN PLACE & PUMP PULLED

	FORCE	ARM	MOMENT
RESISTING FORCES	#		FT.#
CONCRETE	86,296		-702,087
PUMP PIPE	914		- 11,425
WATER (W/ STOP LOGS IN PLACE) ↓	8,737		- 21,843
	95,947#		-735,355 FT.#
OVERTURNING FORCES	#		FT-#
UPLIFT ↑	- 44,724		335,430
EARTH PRESSURES →	(41,232)		238,630
↑	- 44,724#		574,060 FT#
		$\bar{Y}$	
TOTAL FORCES ↓	51,223#	-3.149	-161,295 FT#
→	(41,232#)		

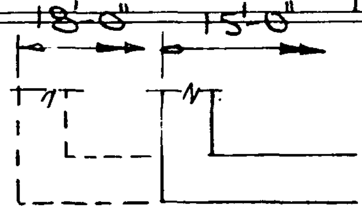
$$e = \frac{15}{2} - 3.149 = 4.351^{FT} \gg \frac{15}{6} = 2.5^{FT}$$

LESS THAN 100% OF BASE IN COMP.

NO GOOD → ADD 3'-0" TO LENGTH OF PUMP STATION

Subject PEORIA LAKE - PUMP STATION		Date 11 APR. 90
Computed by K. WILSON	Checked by DAP	Sheet PS4 of

REV. 20 APR. 90



STABILITY

CASE #1 (CONT)

ADDITIONAL LOADS AND MOMENTS

		FORCE	ARM	MOMENT (FT #)
M_R	BACK WALL	(8,400#)	-3.00	- 25,200
		(- 552)	-3.00	1,656
	SIDE WALLS 150(3.000)(2.000) 2	10,800	-16.50	- 178,200
	BASE SLAB 150(1.167)(6.667)(3.000)	3,501	-16.50	- 57,766
	TOP SLAB 150(4.667)(3.000)	2,100	-15.50	- 32,552
		(-1,060)	-3.00	3,180
		16,401#		- 288,882 FT#
M_o	UPLIFT 62.4(7.167)(6.667)(3.000)	- 8,945	-16.50	147,592 FT#

$$\bar{Y} = \frac{\overset{-302,585}{-161,295 - 288,882 + 147,592}}{\underset{58,679}{51,223 + 16,401 - 8,945}} = -5.157 \text{ FT}$$

$$e = \frac{18}{2} - 5.157 = 3.843 \text{ FT} > \frac{18}{6} = 3.00 \quad \text{No GOOD}$$

ADD TO THICKNESS
BASE SLAB
(TRY ADDING 8")

ADDITIONAL LOAD AND MOMENT	FORCE	ARM	MOMENT (FT #)
(150-62.4)(0.667)(6.667)(16.000)	6,232#	-10.000	-62,327

$$\bar{Y} = \frac{-302,585 - 62,327}{58,679 + 6,232} = -5.622 \text{ FT}$$

$$e = \frac{18}{2} - 5.622 = 3.378 \text{ FT} > \frac{18}{6} = 3.00 \quad \text{No GOOD}$$

Subject PEORIA LAKE - PUMP STATION		Date 26 APR. 90
Computed by K. WILSON	Checked by DAP	Sheet PS5 of

STABILITY

CASE #1 (CONT.)

IN LIEU OF THE PRECEEDING, KEEP THE PUMP STATION 15'-0" LONG AND EXTEND THE BASE SLAB INTO THE EMBANKMENT UNTIL THE RESULTANT FALLS VERY NEAR THE CENTER OF THE BASE.

IF EXTENDED 4 FT		FORCE	ARM	MOMENT
		#		FT #
BASE SLAB	150(1.167)(6.667)(4.00)	4,668 #	-17.00	-79,356
SOIL ABOVE	115(12.00)(6.667)(4.00)	36,802	-17.00	-625,631
	$-115(\pi)(1.083)^2(4.00)$	-1,695	-17.00	28,815
UPLIFT	-62.5(7.167)(6.667)(4.00)	-11,946	-17.00	203,075
		27,829 #		-473,097 FT #

PS3 -634,392

$$\bar{Y} = -\frac{161,295 - 473,097}{51,223 + 27,829} = -8.02^{FT}$$

PS3 79,082

$$e = \frac{19}{2} - 8.022 = 1.478^{FT} < \frac{19}{6} = 3.167^{FT}$$

IF EXTENDED 6 FT	FORCE	ARM	MOMENT
1.50(27,829)	41,744 #	-18.00	-751,392

$$\bar{Y} = -\frac{161,295 - 751,392}{51,223 + 41,744} = -9.817^{FT}$$

$$e = \frac{21}{2} - 9.817 = 0.683^{FT} < \frac{21}{6} = 3.50^{FT}$$

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Subject PEORIA LAKE - PUMP STATION		Date 26 APR. 90
Computed by K. WILSON	Checked by DAP	Sheet PS6 of

STABILITY

CASE # 1 (CONT)

$$\frac{P}{A} \pm \frac{Pe}{S} = \frac{92,967}{6.667(21.00)} \pm \frac{92,967(0.683)(6)}{6.667(21.00)^2}$$

$$= 664.0 \pm 129.6 \qquad 793.6 \text{ PSF}$$

OR

534.4 PSF

CASE # 2

		#	FT #
CONCRETE	PS2	86,296	-702,087
PUMP PIPE, PUMP & H_2O COL.	PS2	4,681	-58,513
WATER	PS2	24,463	-171,241
UPLIFT	PS2	-44,724	335,430
EARTH PRESSURES	PS3	(41,232)	238,630
ADDED HEEL FORCES		41,744	-751,392
		112,460 #	-1,109,173 FT #

$$\bar{Y} = 9.863 \text{ FT}$$

$$e = \frac{21}{2} - 9.863 = 0.637 \text{ FT}$$

$$\frac{P}{A} \pm \frac{Pe}{S} = \frac{112,460}{6.667(21.00)} \pm \frac{112,460(0.637)(6)}{6.667(21.00)^2}$$

$$= 803.2 \pm 146.2 = 949.4 \text{ PSF}$$

OR

657.0 PSF

Subject PEORIA LAKE - PUMP STATION		Date 30 APR. 90
Computed by K. WILSON	Checked by DAP	Sheet PS7 of

STABILITY

BY RESHAPING THE BANK AT THE PUMP STATION LOCATION, SO THAT THE $\frac{\text{MAX. BRG. PRESSURE}}{\text{EARTH UNIT WT.}}$

EQUALS THE EARTH EXCAVATION, THE EXISTING EARTH WILL SUPPORT THE PUMP STATION WITHOUT BEARING FAILURE OR SETTLEMENT PROBLEMS.

$$\text{REQ'D EXCAV. HT.} \simeq \frac{949.4}{115} = 8.26^{\text{FT}}$$

SAY 8'-6" MIN.

CHECK SLIDING.

AT THE BASE OF THE PUMP STATION THERE WILL BE COMPACTED GRANULAR MAT'L, ASSUME THAT $\phi = 35°$.

RESISTING SHEAR; $P_\phi = P_{v_{MIN}} \tan\phi_d$

WHERE $P_{v_{MIN}} = 92{,}967^{\#}$ (SHT. PS 5 - EXTENDED 6^{th})

$\&$ $\phi_d = \tan^{-1}\left[\frac{\tan\phi}{1.5}\right] = \tan^{-1}\left[\frac{\tan 35}{1.5}\right]$

$= 25°$

$$P_\phi = 92{,}967(0.467) = 43{,}397^{\#} > 41{,}232^{\#}$$

LATERAL FORCE

$\therefore$ FS > 1.50 OKAY

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Subject PEORIA LAKE - PUMP STATION		Date 30 APR. 90
Computed by K. WILSON	Checked by DAP	Sheet PS8 of

STABILITY

CHECK SLIDING (CONT.)

BELOW THE GRANULAR MAT'L THE IS CLAY WITH AN UNCONFINED COMPRESSIVE STRESS OF 0.750 TON / FT^2

$$\therefore c = \frac{0.75(2{,}000)}{2} = 750 \text{ PSF}$$

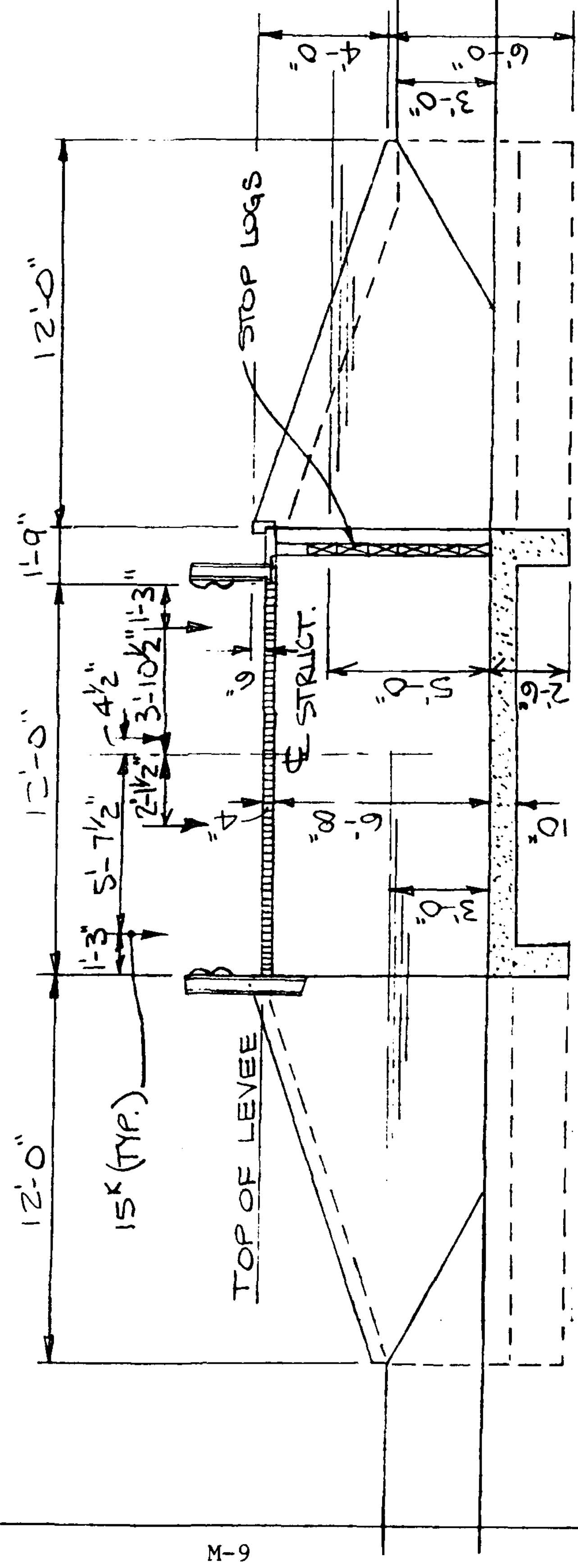
$$P_c = 0.667(750)(6.667)(21.00) = 70{,}038^{\#} > 41{,}232^{\#}$$

↑ LATERAL LOAD.

$\therefore$ FS > 1.50 OKAY

NCR Form 1 Aug 80 381b

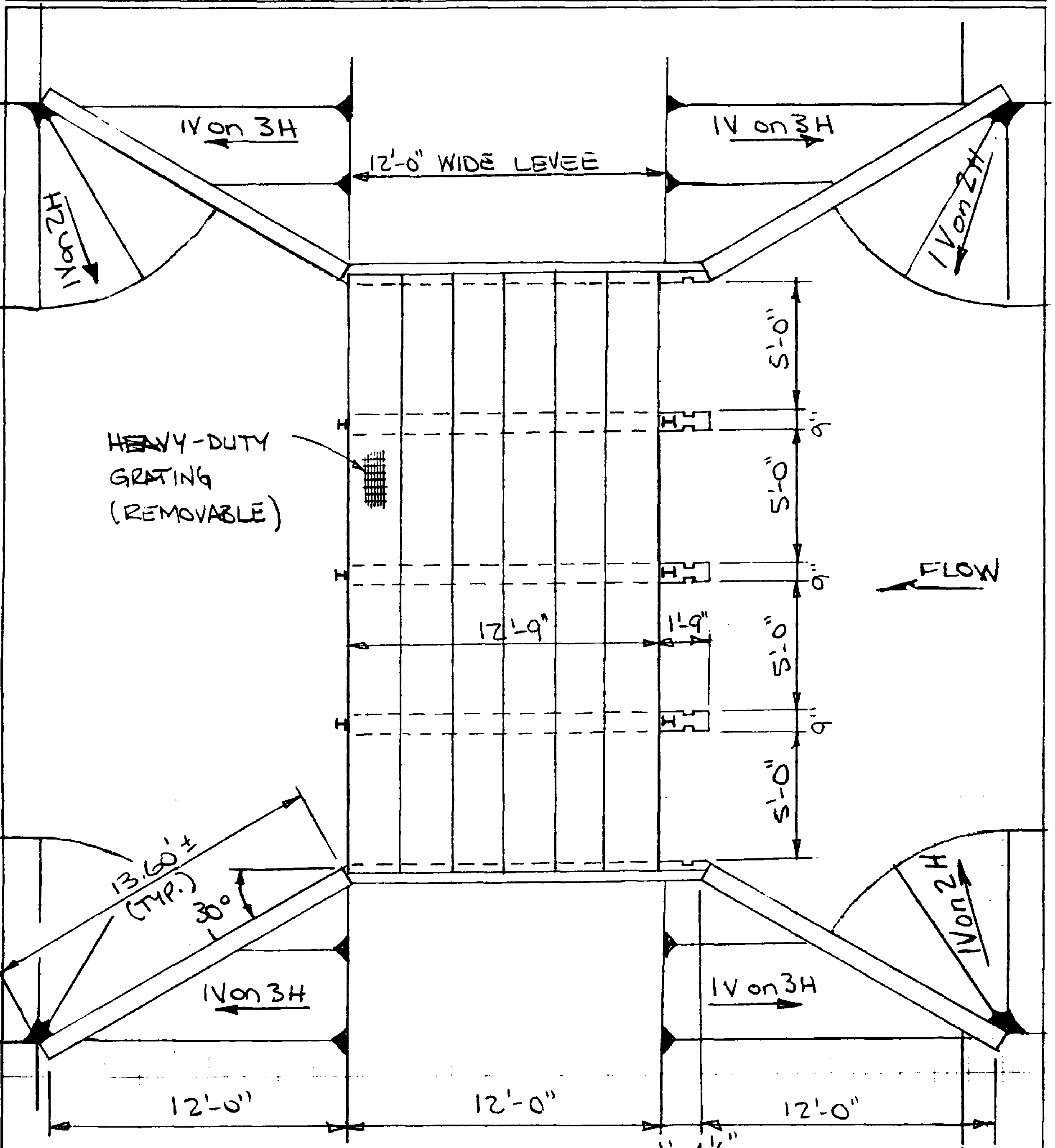
Subject PEORIA LAKE - STOP LOG H_2O CONTROL STRUCT'S.		Date 11 APR. 90
Computed by K. WILSON	Checked by DHP	Sheet 1 of



LONGITUDINAL SECTION

SCALE : 3/16" = 1'-0"

Subject PEORIA LAKE - STOP LOG H_2O CONTROL STRUCTS.		Date 11 APR. 90
Computed by K. WILSON	Checked by DAP	Sheet 2 of



PLAN

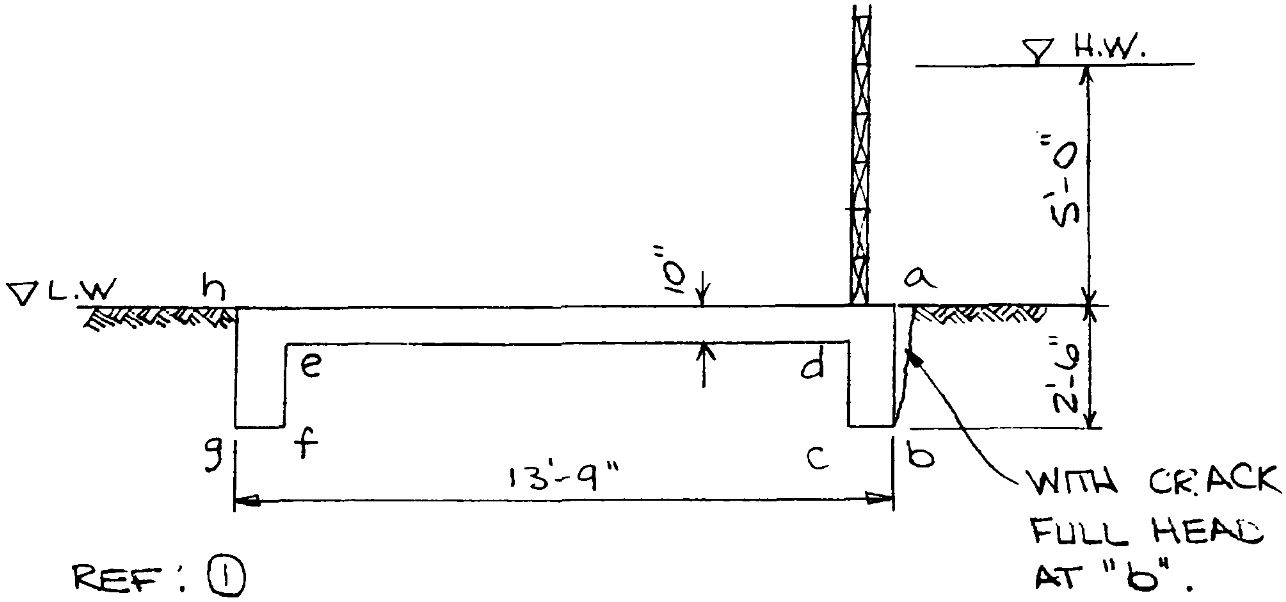
SCALE: 3/16" = 1'-0"

Subject PEORIA LAKE - STOP LOG H_2O CONTROL STRUCT'S. | Date 17 APR. 90

Computed by K. WILSON | Checked by DAP | Sheet 3 of

STABILITY ($\bar{Y}$) (WATER IN UPPER CELL NO WATER IN LOWER CELL)

UPLIFT PRESSURES



REF: (1)

CREEP DISTANCE $= 13'\text{-}9'' + 2(1'\text{-}8'') + 2'\text{-}6'' = 19.584^{FT}$

NET HEAD $= 5'\text{-}0''$

CREEP RATIO $= \dfrac{19.584}{5} = 3.92 \simeq 4.0^{*}$ OKAY

* MIN. ALLOWABLE CREEP RATIO FOR GRANULAR FOUNDATION SOILS.

$$S_p = \frac{\text{NET HEAD}}{L} = \frac{5.0}{19.584} = 0.2553 \ ^{FT}/_{FT}$$

REF: (1) EM 1110-2-2501 WALL DESIGN, FLOOD WALLS

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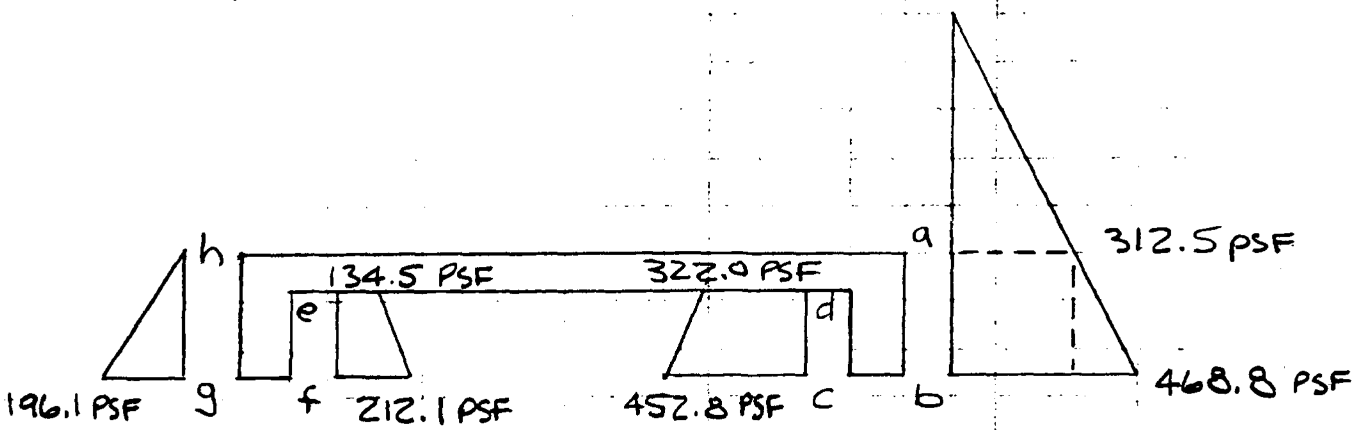
Subject PEORIA LAKE-STOP LOG H_2O CONTROL STRUCTS.		Date 17 APR. 90
Computed by K. WILSON	Checked by DAP	Sheet 4 of

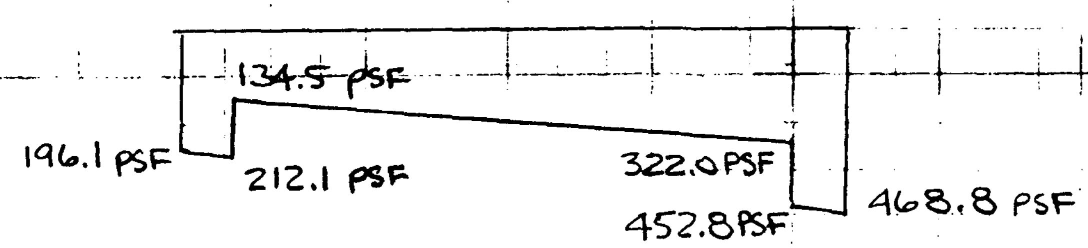
STABILITY $\overline{Y}$

(WATER IN UPPER CELL
NO WATER IN LOWER CELL)

UPLIFT PRESSURES

POINT	CREEP INCREMENT	TOTAL DISTANCE	LOST HEAD	POTENTIAL HEAD	POSITION HEAD	HEAD	PRESSURE
a	0	0	0	5.000	0	5.000	312.5 PSF
b	0	0	0	5.000	2.500	7.500	468.8 "
c	1.000	1.000	0.255	4.745	2.500	7.245	452.8 "
d	1.667	2.667	0.681	4.319	0.833	5.152	322.0 "
e	11.750	14.417	3.681	1.319	0.833	2.152	134.5 "
f	1.667	16.084	4.106	0.894	2.500	3.394	212.1 "
g	1.000	17.084	4.362	0.638	2.500	3.138	196.1 "
h	2.500	19.584	5.000	0	0	0	0





AVG = 204.1 PSF AVG = 460.8 PSF

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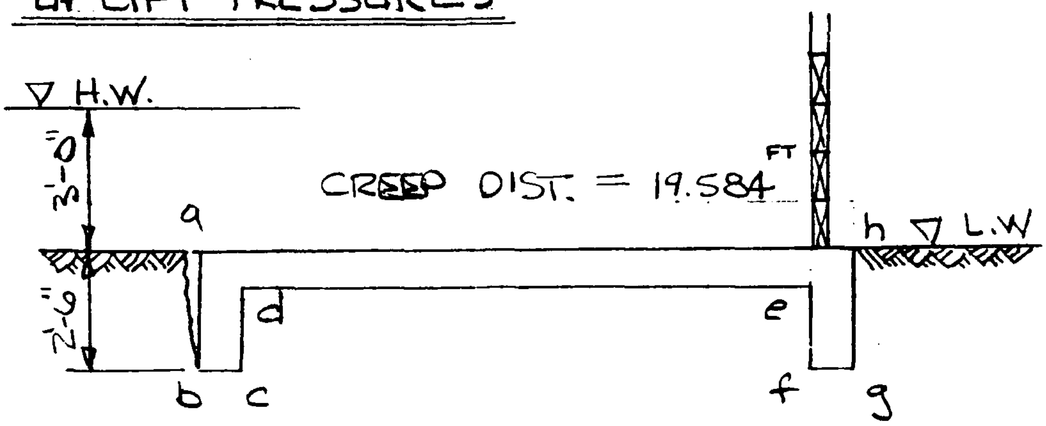
Subject PEORIA LAKE-STOP LOG H_2O CONTROL STRUCTS.		Date 17 APR. 90
Computed by K. WILSON	Checked by DAP	Sheet 5 of

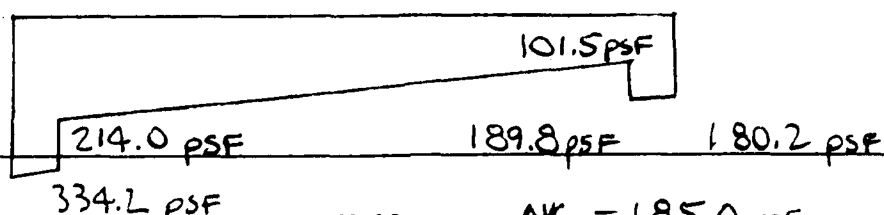
STABILITY ($\bar{Y}$) (WATER IN LOWER CELL NO WATER IN UPPER CELL)

UPLIFT PRESSURES



$$\delta p = \frac{3.0}{19.584} = 0.1532 \text{ FT/FT}$$

POINT	CREEP INCREMENT	TOTAL DISTANCE	LOST HEAD	POTENTIAL HEAD	POSITION HEAD	HEAD	PRESSURE
a	0	0	0	3.000	0	3.000	187.5 PSF
b	0	0	0	3.000	2.500	5.500	343.8 "
c	1.000	1.000	0.153	2.847	2.500	5.347	334.2 "
d	1.667	2.667	0.409	2.591	0.833	3.424	214.0 "
e	11.750	14.417	2.209	0.791	0.833	1.624	101.5 "
f	1.667	16.084	2.464	0.536	2.500	3.036	189.8 "
g	1.000	17.084	2.617	0.383	2.500	2.883	180.2 "
h	2.500	19.584	3.000	0	0	0	0



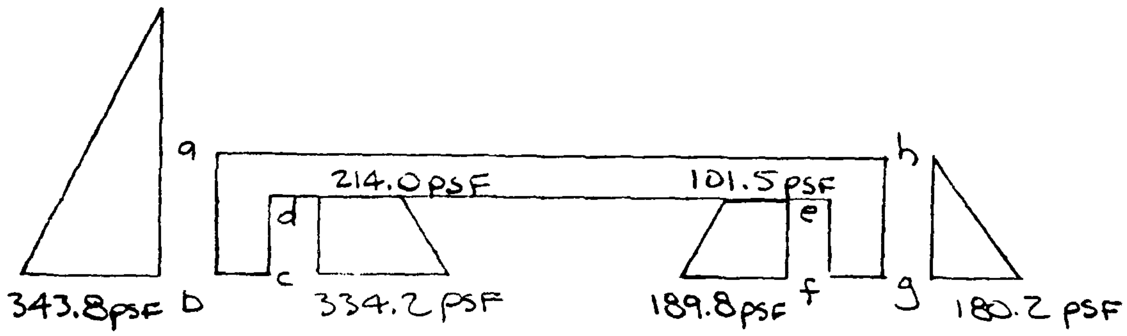
AVG. = 339.0 psf

AVG. = 185.0 psf

Subject PEORIA LAKE - STOP LOG H_2O CONTROL STRUCTS.		Date 17 APR. 9C
Computed by K. WILSON	Checked by DAP	Sheet 6 of

STABILITY ($\bar{Y}$)

(WATER IN LOWER CELL
NO WATER IN UPPER CELL)



NCR Form 381b
1 Aug 80

Subject PEORIA LAKE - STOP LOG H_2O CONTROL STRUCT'S.		Date 16 APR. 90
Computed by K. WILSON	Checked by DAP	Sheet 7 of

STABILITY ($\bar{Y}$) (ABOUT ℄ STR.)

UNIT	FORCE (+↓)	ARM	MOMENT (↷ +)
	#		FT #
GRATING 33.15 (12.00)(22.92)	9,118	-0.875	-7,978
STOP LOGS (OAK) 11.6 (5.33)(4)(6)	1,484	6.167	9,152
WALLS 5 (112.5)(13.75)(6.67)	51,588	—	—
2 (62.5)(13.75)(0.33)	567	—	—
10" SLAB 125 (13.75)(29.75) *	51,133	—	—
10" APRON 2 (125)(1.67)(22.25)	9,289	—	—
	123,179#		1,174 FT #
WING WALLS 4 (112.5)(6.00)(13.60)	36,720#	—	—
4 (112.5)($\frac{4.00}{2}$)(13.60)	12,240	—	—
10" SLAB 4 (125)(13.45)(4.25)	28,581	—	—
	77,541#		—
H 15 TRUCK (TWO AXILS)	15,000#	0.375	5,625 FT-#
	15,000	-5.625	-84,375
	30,000#		-78,750 FT-#
		OR	
	15,000#	3.875	58,125 FT-#
	15,000	-2.125	-31,875
	30,000#		26,250 FT-#
EARTH 120 (7.00)(2)(3.0)(13.75) *	69,300#	—	—
WING WALLS 120 (5.0)(4)(3.0)(12.20)	87,840	—	—
(AVG HEIGHT) (APPROX. LENGTH)	157,140#		—

* ASSUME BASE SLAB EXTENDS 3'-0" OUTSIDE OF ABUTMENT WALLS.

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Subject PEORIA LAKE - STOP LOG H_2O CONTROL STRUCT'S.		Date 17 APR. 90
Computed by K. WILSON	Checked by DAP	Sheet 8 of

STABILITY ($\bar{Y}$) (ABOUT ℄ STRUCT) +↓

UNIT	FORCE	ARM	MOMENT (↷ +)
UPLIFT (WATER IN LOWER CELL NO WATER IN UPPER CELL)	#		FT #
$-339.0(1.00)(29.75)$	-10,085	-6.375	64,292
$-185.0(1.00)(29.75)$	-5,504	6.375	-35,088
$-101.5(11.75)(29.75)$	-35,481	—	—
$-(214.0-101.5)(\frac{11.75}{2})(29.75)$	-19,663	-1.958	38,500
	-70,733#		67,704 FT#
UPLIFT (WATER IN UPPER CELL NO WATER IN LOWER CELL)	#		FT #
$-204.1(1.00)(29.75)$	-6,072	-6.375	38,709
$-460.8(1.00)(29.75)$	-13,709	6.375	-87,395
$-134.5(11.75)(29.75)$	-47,016	—	—
$-(322.0-134.5)(\frac{11.75}{2})(29.75)$	-32,771	1.958	-64,166
	-99,568#		-112,852 FT#

IF UPLIFT ACT ONLY ON THAT PORTION OF THE BASE SLAB BETWEEN THE OUT-TO-OUT OF EXTERIOR WALLS.

NEW FORCE $= \frac{23.75}{29.75}$ (OLD FORCE)			
UPLIFT (UPPER CELL EMPTY)	-56,468#		54,049 FT#
UPLIFT (LOWER CELL EMPTY)	-79,487#		90,092 FT#

Subject: PEORIA LAKE - STOP LOG H_2O CONTROL STRUCT'S.		Date: 17 APR. 90
Computed by: K. WILSON	Checked by: DAP	Sheet 9 of

STABILITY ($\bar{Y}$) (ABOUT ℄ STR.) +↓ +→

UNIT	FORCE	ARM	MOMENT ↷+
WATER (VERT.) (UPPER CELL EMPTY)	#		FT-#
62.5(3.00)(4)(5.0)(12.92)	48,450	-0.417	-20,204
WATER (HORIZ) (UPPER CELL EMPTY)	#		FT-#
343.8 $(\frac{5.5}{2})$(23.75)	22,454	1.833	41,159
- 214.0 (1.67)(23.75)	- 8,488	0.833	- 7,070
- (334.2-214.0)$(\frac{1.67}{2})$(23.75)	- 2,384	0.556	- 1,325
101.5 (1.67)(23.75)	4,026	0.833	3,353
(189.8 - 101.5)$(\frac{1.67}{2})$(23.75)	1,751	0.556	974
- 180.2 $(\frac{2.5}{2})$(23.75)	- 5,350	0.833	- 4,456
(SEE SHT. 6)	12,009#		32,635 FT-#
WATER (HORIZ) (LOWER CELL EMPTY)	#		FT-#
-468.8 $(\frac{7.5}{2})$(23.75)	-41,753	2.500	-104,381
322.0 (1.67)(23.75)	12,771	0.833	10,639
(452.8 - 322.0)$(\frac{1.67}{2})$(23.75)	2,594	0.556	1,442
- 134.5 (1.67)(23.75)	- 5,335	0.833	- 4,444
- (212.1 - 134.5)$(\frac{1.67}{2})$(23.75)	- 1,539	0.556	- 856
196.1 $(\frac{2.5}{2})$(23.75)	5,822	0.833	4,849
(SEE SHT. 4)	-27,440#		- 92,751 FT-#

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Subject PEORIA LAKE - STOP LOG H_2O CONTROL STRUCT'S	Date 17 APR. 90
Computed by K. WILSON / Checked by DAP	Sheet 10 of

STABILITY (?) (ABOUT ℄ STR)

SUMMATION OF FORCES

	FORCE (+↓, →+)	MOMENT (+)
CASE 1 (NO WATER IN CELLS)		
CONTROL STRUCTURE W/O WING WALLS	123,179#	1,174 FT#
H 15 TRUCK	30,000	-78,750
EARTH (ON BASE SLAB OUTSIDE ABUTMENT WALLS)	69,300	—
↓	222,479#	-77,576 FT#
CASE 2 (WATER IN UPPER CELL NO WATER IN LOWER CELL)		
CONTROL STRUCTURE W/O WING WALLS	123,179#	1,174 FT#
EARTH (SEE ABOVE)	69,300	—
UPLIFT	-99,568	-112,852
↓	92,911#	-111,678 FT#
ADD H15 TRUCK (CASE 2A)	30,000	-78,750
↓	122,911#	-190,428 FT#
LATERAL WATER LOADS P_{H_2O} ←	-27,440#	-92,751 FT#
CASE 2	92,911#	-204,429 FT#
CASE 2A	122,911#	-283,179 FT#

Subject PEORIA LAKE - STOP LOG H_2O CONTROL STRUCT'S.		Date 18 APR. 90
Computed by K. WILSON	Checked by DAP	Sheet 11 of

STABILITY ($\bar{Y}$) (ABOUT ℄ STR)

SUMMATION OF FORCES (CONT.)

	FORCE (+↓, →+)	MOMENT (↷+)
CASE 3 (WATER IN LOWER CELL NO WATER IN UPPER CELL)		
CONTROL STRUCTURE w/o WING WALLS	123,179 #	1,174 FT-#
EARTH (SEE CASE 1)	69,300	–
WATER	48,450	–20,204
UPLIFT	–70,733	67,704
↓	170,196 #	48,674 FT-#
ADD H15 TRUCK (CASE 3A)	30,000	26,250
↓	200,196 #	74,512 FT-#
LATERAL WATER LOADS P_{H_2O} →	12,009	32,635
CASE 3	170,196 #	81,309 FT #
CASE 3A	200,196 #	107,147 FT-#

SOIL PRESSURES NOTE: ASSUME CONTROL STRUCT. W/O WING WALLS

CASE 1 $(e = 0.3487) < B/6 = 13.75/6 = 2.2917$

$$\frac{P}{A} \pm \frac{Mc}{I} = \frac{222,479}{13.75(29.75)} \pm \frac{77,576(6.875)(12)}{29.75(13.75)^3}$$

$$= 543.88 \pm 82.75 = 626.63 \text{ PSF}$$

OR

461.13 PSF

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STABILITY ($\bar{Y}$) (ABOUT ℄ STR.)

SOIL PRESSURES (CONT.)

CASE 2 $(e = 2.2003) < B/6 = 2.2917$

$$\frac{P}{A} \pm \frac{Mc}{I} = \frac{92,911}{409.06} \pm \frac{204,429}{937.43}$$

$$= 227.13 \pm 218.07 = 445.20 \text{ PSF}$$

OR

9.06 PSF

CASE 2 A $(e = 2.3039) > B/6 = 2.2917$

$$\frac{P}{A} \pm \frac{Mc}{I} = \frac{122,911}{409.06} \pm \frac{283,179}{937.43}$$

$$= 300.47 \pm 302.08 = 602.55 \text{ PSF}$$

OR

− 1.61 PSF

CASE 3 $(e = 0.4777) < B/6 = 2.2917$

$$\frac{P}{A} \pm \frac{Mc}{I} = \frac{170,196}{409.06} \pm \frac{80,309}{937.43}$$

$$= 416.07 \pm 86.74 = 502.81 \text{ PSF}$$

OR

329.33 PSF

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STABILITY ($\bar{Y}$) (ABOUT ℄ STR.)

SOIL PRESSURES (CONT.)

CASE 3A $(e = 0.5352) < B/6 = 2.2917$

$$\frac{P}{A} \pm \frac{Mc}{I} = \frac{200{,}196}{409.06} \pm \frac{107{,}147}{937.43}$$

$$= 489.40 \pm 114.30 = 603.70 \text{ PSF} \text{ OR } 375.10 \text{ PSF}$$

DUE TO THE HIGH MOMENTS IN CASES 2 AND 2A CONSIDER MOVING THE STOP LOGS TO THE OTHER SIDE OF THE CONTROL STRUCT. SO WATER CAN BE ON THE BASE SLAB WHEN WATER IS IN THE UPPER CELL.

UNIT	FORCE	ARM	MOMENT
WATER (VERT.) (UPPER CELL FULL) 62.5 (5.00)(4)(50)(12.92)	80,750	0.417	33,673 FT.#

NEW SUMMATION OF FORCES	FORCE	MOMENT
CASE 2 (REV.)	92,911 #	-204,429 FT.#
ADD WATER (VERT)	80,750	33,673
	173,661 #	-170,756 FT#
CASE 2A (REV.)	122,911 #	-283,179 FT#
ADD WATER (VERT)	80,750	33,673
	203,661	-249,506 FT

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STABILITY ($\bar{Y}$) (ABOUT ℄ STR)

NEW SUMMATION OF FORCES (CONT.)

	FORCE	MOMENT
CASE 3 (REV.)	170,196#	81,309 FT#
OMIT WATER (VERT) (SEE SHT.)	−(48,450)	−(−20,204)
	121,746#	101,513 FT#
CASE 3A (REV.)	200,196#	107,147 FT#
	−(48,450)	−(−20,204)
	151,746#	127,351

NEW SOIL PRESSURES

CASE 2 (REV) $(e = 0.9833) < B/6 = 2.2917$

$$\frac{P}{A} \pm \frac{Mc}{I} = \frac{173{,}661}{409.06} \pm \frac{170{,}756}{937.43}$$

$$= 424.54 \pm 182.15 = 606.69 \text{ PSF}$$

OR

$$242.39 \text{ PSF}$$

CASE 2A (REV) $(e = 1.2251) < B/6 = 2.2917$

$$\frac{P}{A} \pm \frac{Mc}{I} = \frac{203{,}661}{409.06} \pm \frac{249{,}506}{937.43}$$

$$= 497.88 \pm 266.16 = 764.04 \text{ PSF}$$

OR

$$231.72 \text{ PSF}$$

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STABILITY ($\bar{Y}$) (ABOUT ℄ STR.)

NEW SOIL PRESSURES (CONT.)

CASE 3 (REV.) ($e = 0.8334 < B/6 = 2.2917$

$$\frac{P}{A} \pm \frac{Mc}{I} = \frac{121,746}{409.06} \pm \frac{101,513}{937.43}$$

$$= 297.62 \pm 108.29 = 405.91 \text{ PSF}$$

OR

$$189.34 \text{ PSF}$$

CASE 3A (REV.) ($e = 0.8392$) $< B/6 = 2.2917$

$$\frac{P}{A} \pm \frac{Mc}{I} = \frac{151,746}{409.06} \pm \frac{127,351}{937.43}$$

$$= 370.96 \pm 135.85 = 506.81 \text{ PSF}$$

OR

$$235.11 \text{ PSF}$$

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BEARING CAPACITY

SOIL BORINGS PM-89-1, PM-89-2 & PM-89-4 SHOW BLOW COUNTS AS LOW AS 2 FOR CL GR. LEAN CLAY AND CL-CH GR. MEDIUM CLAY AT THE BASE OF THE WATER CONTROL STRUCTURES. THE BLOW COUNT DOES NOT INCREASE APPRECIABLY WITH DEPTH.

q_u = UNCONFINED COMPRESSIVE STRENGTH = 0.250 TON/FT^2

C = COHESION = $\frac{q_u}{2} = \frac{0.250(2{,}000)}{2} = 250$ PSF

$$q_{ULT} = C N_c F_{cs} F_{cd} F_{ci} + q N_q F_{qs} F_{qd} F_{qi} + \frac{1}{2} \gamma \overline{B} N_\gamma F_{\gamma s} F_{\gamma d} F_{\gamma i}$$

Eq (3.16), REF. 1

$\phi = 0°$ $\therefore N_c = 5.14$, $N_q = 1.00$ AND $N_\gamma = 0$ TABLE 3.2

$$\therefore q_{ULT} = C N_c F_{cs} F_{cd} F_{ci} + q N_q F_{qs} F_{qd} F_{qi}$$

$$Q_{ULT} = \overline{B} (q_{ULT}) L$$

REF. 1 "PRINCIPLES OF FOUNDATION ENGINEERING", DAS,

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BEARING CAPACITY (CONT.)

$$F_{cs} = 1 + \frac{B'}{L}\left(\frac{N_q}{N_c}\right) \quad \text{Eq. (3.20)}$$

DUE TO ECCENTRICALLY LOADED FOUNDATION SUBSTITUTE B' FOR B

$$B' = B - 2e$$

$$F_{qs} = 1 + \frac{B'}{L}\tan\phi \quad \text{Eq (3.21)}, \ \phi = 0$$

$$= 1.0$$

$$F_{cd} = 1 + 0.4\frac{D_f}{B'} \quad \text{Eq. (3.23)}$$

$$F_{qd} = 1 + 2\tan\phi\,(1-\sin\phi)^2\frac{D_f}{B'} \quad \text{Eq. (3.24)}, \ \phi = 0$$

$$= 1.0$$

$$F_{ci} = F_{qi} = \left(1 - \frac{\beta^\circ}{90^\circ}\right)^2 \quad \text{Eq. (3.29)}$$

$$\beta = \text{VARIES} = \arctan\frac{\Sigma H}{\Sigma V}$$

NOTE: THERE IS NO SLOPING BACKFILL OR INCLINED FOUNDATION, THEREFORE, THERE ARE NO FACTORS FOR THOSE ITEMS.

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BEARING CAPACITY (CONT.)

CASE # 1 (NO STOP LOGS - WITH TRUCK)

$$B' = B - 2e = 13.75 - 2(0.3487) = 13.05'$$

$$L = 29.75'$$

$$F_{cs} = 1 + \frac{B'}{L}\left(\frac{N_q}{N_c}\right) = 1 + \frac{13.05}{29.75}\overset{0.195}{\left(\frac{1.00}{5.14}\right)} = 1.085$$

$$F_{cd} = 1 + 0.4\left(\frac{D_f}{B'}\right) = 1 + 0.4\left(\frac{2.5}{13.05}\right) = 1.076$$

$$\beta = 0°$$

$$F_{ci} = F_{ci} = 1.00$$

$$q_{ULT} = 250(5.14)(1.085)(1.076)(1.00) + (115-62.5)(0.833)(1.0)(1.0)(1.0)(1.0)$$

$$= 1,500 + 44 = 1,544 \text{ PSF}$$

$$Q_{ULT} = 13.05(1,544)(29.75) = 599,438^{\#}$$

$$FS = \frac{599,438}{222,479} = 2.69 > 2.00$$

OKAY DUE TO TRUCK LOCATION AND SIZE

SHT. 11

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BEARING CAPACITY (CONT.)

CASE # 2 (REV) (WATER IN UPPER CELL - NO TRUCK)

$$B' = 13.75 - 2(0.9833) = 11.78$$

$$F_{cs} = 1 + \frac{11.78}{29.75}(0.195) = 1.077$$

$$F_{cd} = 1 + 0.4\left(\frac{2.5}{11.78}\right) = 1.084$$

$$\beta = \arctan \frac{27,440}{173,661} = 8.98^{\circ}$$

$$F_{ci} = F_{qi} = \left(1 - \frac{8.98}{90}\right)^2 = 0.810$$

$$q_{ULT} = 250(5.14)(1.077)(1.084)(0.810)$$

$$+ (115 - 62.5)(0.83)(1.0)(1.0)(1.0)(0.810)$$

$$= 1,215 + 35 = 1,250 \text{ PSF}$$

$$Q_{ULT} = 11.78(1,250)(29.75) = 438,069^{\#}$$

$$FS = \frac{438,069}{173,661} = 2.52 < 3.00 \quad \text{NO GOOD}$$

SHT. 14

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BEARING CAPACITY (CONT.)

CASE # 2A (REV.) (WATER IN UPPER CELL - WITH TRUCK)

$$B' = 13.75 - 2(1.2251) = 11.30$$

$$F_{cs} = 1 + \frac{11.30}{29.75}(0.195) = 1.074$$

$$F_{cd} = 1 + 0.4\left(\frac{2.5}{11.30}\right) = 1.088$$

$$\beta = \text{arc tan} \frac{27,440}{203,661} = 7.67°$$

$$F_{ci} = F_{qi} = \left(1 - \frac{7.67}{90}\right)^2 = 0.836$$

$$q_{ULT} = 250(5.14)(1.074)(1.088)(0.836)$$

$$+ (115 - 62.5)(0.83)(1.0)(1.0)(1.0)(0.836)$$

$$= 1,255 + 36 = 1,291 \text{ psf}$$

$$Q_{ULT} = 11.30(1,291)(29.75) = 434,146^{\#}$$

$$FS = \frac{434,146}{203,661} = 2.13 > 2.00 \quad \text{OKAY}$$

← SHT. 14

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BEARING CAPACITY (CONT.)

CASE # 2 (WATER IN UPPER CELL - NO TRUCK)

$$B' = 13.75 - 2(2.2003) = 9.35$$

$$F_{cs} = 1 + \frac{9.35}{29.75}(0.195) = 1.061$$

$$F_{cd} = 1 + 0.4\left(\frac{2.5}{9.35}\right) = 1.107$$

$$\beta = \arctan \frac{27{,}440}{92{,}911} = 16.45^\circ$$

$$F_{ci} = F_{qi} = \left(1 - \frac{16.45}{90}\right)^2 = 0.669$$

$$q_{ult} = 250(5.14)(1.061)(1.107)(0.669) + 52.5(0.83)(1.0)(1.0)(1.0)(0.669)$$

$$= 1{,}010 + 29 = 1{,}039 \text{ PSF}$$

$$Q_{ult} = 9.35(1{,}039)(29.75) = 289{,}010^{\#}$$

$$FS = \frac{289{,}011}{92{,}911} = 3.11 > 3.00 \quad \text{OKAY}$$

SHT 12

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BEARING CAPACITY (CONT.)

CASE 2A (WATER IN UPPER CELL - WITH TRUCK)

$$B' - 13.75 - 2(2.3039) = 9.14$$

$$F_{cs} = 1 + \frac{9.14}{29.75}(0.195) = 1.060$$

$$F_{cd} = 1 + 0.4\frac{(2.5)}{9.14} = 1.109$$

$$\beta = \arctan \frac{27,440}{122,911} = 12.59°$$

$$F_{ci} + F_{qi} = \left(1 - \frac{12.59}{90}\right)^2 = 0.740$$

$$q_{ULT} = 250(5.14)(1.060)(1.109)(0.740) + 52.5(0.83)(1.0)(1.0)(1.0)(0.740)$$

$$= 1,118 + 32 = 1,150 \text{ PSF}$$

$$Q_{ULT} = 9.14(1,150)(29.75) = 312,702^{\#}$$

$$FS = \frac{312,702}{122,911} = 2.54 > 2.00 \quad \text{OKAY}$$

↑ SHT 12

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STABILITY

SLIDING RESISTANCE

$$P_c = 0.667(250)(13.75)(29.75) = 68,211^{\#}$$

LATERAL WATER LOADS $= 27,440^{\#} < 68,211^{\#}$

$\therefore$ FS > 1.50 OKAY

IF STRUCTURE IS FOUNDED ON GRANULAR MAT'L.

$$P_\phi = P_{v_{min}} \tan \phi_d \qquad \text{ASSUME } \phi = 35^\circ$$

$$\phi_d = \tan^{-1}\left[\frac{\tan\phi}{1.5}\right] = \tan^{-1}\left[\frac{\tan 35}{1.5}\right] = 0.467$$

$$P_\phi = 92,911(0.467) = 43,389 > 27,440^{\#}$$

$\therefore$ FS > 1.50 OKAY

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PUMP STATION
MECHANICAL/ELECTRICAL CONSIDERATIONS

A
P
P
E
N
D
I
X

N

UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
DEFINITE PROJECT REPORT
WITH INTEGRATED ENVIRONMENTAL ASSESSMENT (R-6F)

PEORIA LAKE ENHANCEMENT
PEORIA POOL, ILLINOIS WATERWAY, RIVER MILES 178.5 TO 181
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APPENDIX N
PUMP STATION
MECHANICAL AND ELECTRICAL CONSIDERATIONS

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PEORIA POOL, ILLINOIS WATERWAY, RIVER MILES 178.5 TO 181
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APPENDIX N
PUMP STATION
MECHANICAL AND ELECTRICAL CONSIDERATIONS

N-1. PURPOSE AND SCOPE.

The purpose of this appendix is to present the preliminary mechanical and electrical design of the Peoria Lake pump station. Pump station sizing and layout are based on the required capacity, efficient operation of the station, ease of normal maintenance, and access requirements. Pump manufacturers' engineering data for standard catalog units were used to develop the design presented in this appendix.

N-2. STATION DESCRIPTION.

A pump station containing one submersible type propeller pump is proposed to flood the Forested Wetland Management Area (FWMA). The flooded region then would be used by migratory waterfowl.

The pump station intake will be located on the southern edge of the FWMA connected to an existing man-made ditch which is an extension of Peoria Lake. The depth of the ditch averages approximately 6 feet, which is adequate to meet station requirements. The pump station will supply water to an elevated discharge point within cell A (the highest in elevation of the three proposed cells). From cell A, water can be manipulated by gravity flow and stoplog structures in cells A, B, and C to allow independent water level control in any of the three cells.

The pump station is sized to complete a 2-foot water level fill in all three cells in less than 10 days from an empty condition.

All necessary power and control equipment for the pump unit will be located outside of the pump station on an elevated wood platform assembly.

The pump station structure will consist of cast-in-place concrete sections. One 6,000-gpm submersible-type propeller pump will be utilized to flood the

FWMA. The steel pump discharge pipe will transition to 24-inch reinforced concrete pipe (RCP) near the pump station wall. Approximately 400 feet of 24-inch RCP will be required to reach the discharge location in cell A. The discharge assembly will be constructed with a grated opening at elevation 449.0. This elevation is 1 foot above the maximum ponding elevation in cell A. Therefore, inadvertent drainage of cell A by reversed flow through the pump will be prevented. Pump selection calculations are presented on plates N-1 through N-12.

Pump unit removal will be accomplished through a secured and sealed discharge tube access cover. Access to the inside of the pump station will be by a sealed manway type opening at the top of the station. A hand-cleanable trash rack will be provided at the intake point for protection of the impeller against large debris. Dewatering of the sump for maintenance purposes will be possible after isolating the sump from the water source by the use of stoplogs. Layout of the station is shown on plate 18 of the main report.

N-3. OPERATION.

The pump unit will be manually operated. Automatic pump shutoff protection capability for a low sump level condition will be provided via redundant float switches located in the sump. The float switches' contacts will open, preventing pump operation at a sump elevation of approximately elevation 436.8. This setpoint maintains an adequate margin of protection for the pump and motor according to the pump minimum submergence requirement.

In addition, an appropriate time delay circuit will be incorporated into the pump motor logic to prevent pump initiation while reverse water flow (contained within the discharge pipe) is occurring. This reverse flow situation will occur once the pump is shut off either manually or automatically. The discharge pipe to cell A will be pitched to minimize flow reversal through the pump.

The annual operating cost due to energy consumption is estimated at $1,075 and is calculated on plates N-13 through N-15.

N-4. ELECTRICAL.

Central Illinois Light Company (CILCO) of Peoria, Illinois, is the local electric utility serving the area. Two medium voltage power systems are available in the area; 13.2 kV 3-phase and 7.62 kV single-phase. The 3-phase line connection is located approximately 1.2 miles from the station. The single-phase connection is located approximately 800 feet from the station and requires a phase converter for utilization. The single-phase service has been selected as the primary source of power due to lower total life cycle costs. Electrical usage will be billed the same regardless of which power source is utilized according to the applicable rate structure.

Approximately 800 feet of new buried conduit will be required to bring the 7.26 kV source to the site. Near the pump station, the 7.26 kV line will be transformed down with a 50 kVA transformer to 240 V single-phase, which, in turn, will be converted to 480 V 3-phase using a power phase converter. The transformer, kilowatt-hour meter, power phase converter, pump control panel, and a receptacle for utility/maintenance purposes will be mounted on an elevated wooden platform assembly located approximately 20 feet from the pump station and above the 100-year event elevation. Cables to the pump station will be installed underground in metal conduit.

Local ownership of the power source will be on the load side of the kilowatt-hour meter. CILCO will own and maintain the medium voltage service, transformer, and meter.

Electrical calculations for the pump station are shown on plates N-16 through N-23. An electrical one-line diagram and details are shown on plate 20 of the main report.

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I Determine System Head losses

A. Intake water Elevation Inside Structure ≈ 440'
B. Maximum Ponding Elevation Inside cell A ≈ 448'
C. Vertical Discharge Pipe Discharge Elevation ≈ 449.17'
D. Width (actual) of Intake Trash Rack ≈ 56"
E. Sediment Lip Rises to Elevation ≈ 435.5'
F. Trash rack Consists of 3/8" square bars w/ 2" clearance Between Bars ∴ 23 - 2" openings
G. Pipe to cell A Consists of ≈ 400' of 24" RCP
F. System Losses Include:
   1. Intake square orifice loss (h_o)
   2. Trashrack Loss (h_{TR})
   3. Pump pipe Friction Loss (h_P)
   4. Discharge Elbow Loss (h_e)
   5. Concrete pipe friction Loss (h_{CCP})
   6. Discharge Riser Elbow Loss (h_{RE})
   7. Discharge Loss (h_d)
   8. Static Head (h_s)
   9. Discharge Expansion Loss (h_{DE}) 24"-48" Transition
H. 6000 GPM pumping capacity

1. Net Area of opening $= 4' \times 23(2'') \times \frac{Ft}{12''} = 15.33\ FT^2$.

(Approx 4'x4' opening)

From Brater & King "Handbook of Hydraulics" pp. 4-21 the following eq applies for submersed orifice:

$$Q = C a \sqrt{2g\, h_o}$$

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where $\dot{Q}$ [ft³/s] g [32.2 ft/s²]
h_o [ft] C [discharge Coefficient]
a [ft²]

From Table 4-6 Assume $C \approx 0.614$

$$\dot{Q} = \frac{6000\ \text{Gallons}}{\text{min}} \times \frac{1\ \text{min}}{60\ \text{sec}} \times \frac{1\ \text{FT}^3}{7.48\ \text{gallons}} = 13.4\ \text{FT}^3/\text{s}$$

$$\therefore \quad Q = C a \sqrt{2 g h_o}$$

$$h_o = \left(\frac{Q}{Ca}\right)^2 \times \frac{1}{2g}$$

$$h_o = \left(\frac{13.4}{0.614(15.33)}\right)^2 \times \frac{1}{2(32.2)}$$

$$\boxed{h_o = 0.03\ \text{ft}}\ \checkmark$$

2. Reference "New Concepts in the Design of Propeller Pumping Stations" by Vincenzo Bixio pp. 71

Assume $\phi \approx 70°$
$a_o = 2''$
$S_1 = 2\,3/8''$
No. 1 Type Bars (Square edged)

V_1 (approach velocity)
$V_1 = Q/A$

$$= \frac{6000\ \text{Gallons}}{\text{min}} \times \frac{1\ \text{FT}^3}{7.48\ \text{gallons}} \times \frac{1\ \text{min}}{60\ \text{sec}} \times \frac{1}{4' \times \frac{56''}{12}} = 0.72\ \text{FT/s}$$

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$q_o/S_1 = 0.84$
$K_1 = 0.11$
$\beta_1 = 2.34$

$$h_{TR} = \frac{V_1^2}{2g}\beta_1 K_1 \sin\phi \qquad \text{for } Re = \frac{V_o q_o}{\nu} > 10^4$$

$$h_{TR} = \frac{(0.72)^2}{2(32.2)} 2.34(0.11)(\sin 70)$$

$\nu = 1.082\times10^{-5}\ ft^2/s$
$q_o = 2''$
$V_o = 0.872\ ft/s$
$Re = 1.3\times10^4$ ok

$$\boxed{h_{TR} = 0.002\ ft}$$

3. Assume approximately 12 FT of 27" steel pipe (ID)

$V = Q/A$

$$= \frac{6000\ Gallons}{min} \times \frac{1 min}{60 sec} \times \frac{1\ FT^3}{7.48\ gallons} \times \frac{1}{\frac{\pi(\frac{27}{12})^2}{4} FT^2}$$

$V = 3.36\ FT/S$

$$Re = \frac{VD}{\nu} = \frac{3.36(\frac{27}{12})}{1.082\times10^{-5}} = 7\times10^5 \checkmark$$

Reference "Fluid Mechanics" F.M. White pp. 332-333
ε (commercial steel) ≈ 0.00015 FT
ε/D (relative roughness) $\approx 0.00015/\frac{27}{12} = 0.0001$

From Moody chart, read friction factor $f \approx 0.02$

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$$h_p = f \frac{L}{D} \frac{V^2}{2g}$$

$$= 0.02 \frac{(12)}{\left(\frac{27}{12}\right)} \frac{(3.36)^2}{2(32.2)}$$

$$\boxed{h_p = 0.019 \text{ ft}}$$

4. Reference "New Concepts in the Design of propeller Pumping Stations" by Vincenzo Bixio pp83

For ~700mm pipe & E_2 type elbow
Assume E_2 ϕ600mm for determination of elbow head loss

$$6000 \frac{\text{gallons}}{\text{min}} \times \frac{0.0631 \text{ L/s}}{1 \text{ gpm}} = 379 \text{ L/s}$$

$\therefore$ Fromm chart, read $h_e \approx 0.05$ m

$$0.05\text{m} \times \frac{1 \text{ FT}}{0.305\text{m}} = 0.16 \text{ FT}$$

$$\boxed{h_e = 0.16 \text{ Ft}}$$

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PLATE N-4

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5. Assume 400 ft of 24" RCP

$V = Q/A$

$= \frac{6000 \text{ Gallons}}{\text{min}} \times \frac{1 \text{ min}}{60 \text{ sec}} \times \frac{1 FT^3}{7.48 \text{ gallons}} \times \frac{1}{\frac{\pi(2)^2 FT^2}{4}}$

$V = 4.25 \text{ FT/s}$

$Re = \frac{VD}{\nu} = \frac{4.25(2)}{1.082 \times 10^{-5}} = 7.9 \times 10^5$

Reference "Fluid Mechanics" F.M. White pp 332-333

ε (concrete pipe) $\approx$ 0.001 ft

ε/D (relative roughness) $\approx 0.001/2 = 0.0005$

From Moody chart, read friction factor $f \approx 0.0175$

$h_{RCP} = f \frac{L}{D} \frac{V^2}{2g}$

$= 0.0175 \frac{(400)}{2} \frac{(4.25)^2}{2(32.2)}$

$\boxed{h_{RCP} = 0.98 \text{ FT}}$

6. Reference F.M. White "Fluid Mechanics" pp 355

Assume formed ell with R/D ratio $\approx$ 1.5

ε/D is 0.0005 determined from #5.

$\therefore$ Read $K \approx 0.24$

$h_{RE} = K\, V^2/2g = 0.24 \frac{(4.25)^2}{2(32.2)}$

$\boxed{h_{RE} = 0.07 \text{ FT}}$

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7. Assume 48" Discharge pipe

$v = Q/A$

$= 6000 \frac{\text{gallons}}{\text{min}} \times \frac{1 \text{ min}}{60 \text{ sec}} \times \frac{1 \text{ FT}^3}{7.48 \text{ Gallons}} \times \frac{1}{\frac{\pi(4)^2}{4}}$

$v = 1.06 \text{ FT/s}$

$$h_d = v^2/2g = \frac{(1.06)^2}{2(32.2)} = 0.02 \text{ FT}$$

$\boxed{h_d = 0.02 \text{ FT}}$

8. Static head is the difference in elevation from the intake water level (440' - Flat pool) to the Top of the discharge pipe (449')

$h_s = 449.17' - 440' = 9.17'$

$\boxed{h_s = 9.17 \text{ FT}}$

9. Reference F.M. White "Fluid Mechanic" pp 357 For sudden expansion $d/D = 24''/48 = 0.5$ Read $K \approx 0.5$

$$h_{oe} = K\, V^2/2g = \frac{0.5(4.25)^2}{2(32.2)} = 0.14 \text{ ft}$$

$\boxed{h_{oe} = 0.14}$

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$$TDH_{@6000\,GPM} = h_o + h_{TR} + h_p + h_e + h_{REP} + h_{RE} + h_d + h_s + h_{DE}$$

$$TDH_{@6000\,GPM} = 0.03 + 0.002 + 0.019 + 0.16 + 0.98 + 0.07 + 0.02 + 9.17 + 0.14$$

$$\underline{\underline{TDH_{@6000\,GPM} = 10.6\ FT}}$$

II Pump Selection

FLYGT submersible propeller pump (20 KW shaft rating)
Model 7050, 700 RPM, 4 blades @ angle 14°
Q = 6000 GPM @ 10.6 TDH w/ $\eta \approx 81\%$

1. Pump Specific Speed @ BEP

$$N_S = \frac{N\,Q^{1/2}}{H^{3/4}} = \frac{700\,(5600)^{1/2}}{(10.5)^{3/4}} = 8980$$ ∴ ok for propeller type

2. Pump input power requirement
Assume $\eta_{motor} \approx 0.85$

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$$\text{Input power} = \frac{\text{Water Hp}}{\eta_{pump}\,\eta_{motor}}$$

$$= \frac{GPM \times TDH}{3960(0.81)(0.85)}$$

$$= \frac{6000 \times 10.6}{3960(0.81)(0.85)}$$

$$\text{Input power} = 23.3\ Hp \times \frac{0.746\,KW}{Hp} = 17.4\ KW \therefore ok$$

Use 30 Hp motor

3. Submergence Requirement
   - per Manufacturer 20" minimum from inlet flange
   - actual Submergence:
     sump water elevation − inlet flange elevation
     440' − 435.2' or 57.6" ∴ ok

4. NPSH Check (Based on inlet flange depth)

$$NPSH_{req} \overset{?}{\leq} NPSH_{avail}$$

$$4\,m \overset{?}{\leq} \frac{P_a - P_v}{\gamma} + H_{submergence}$$

per Manufacturer

P_a = P @ surface = 14.7 PSIA
P_v = vapor pressure H_2O @ 90°F = 0.6982 PSIA
γ = 62.11 lb/ft^3 @ 90°F
H = 57.6"

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PLATE N-8

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$$13.1\ ft \overset{?}{\leq} \frac{(14.7 - 0.6982)\ PSIA}{62.11\ lb/ft^3} \times \frac{144\ in^2}{1\ ft^2} + 57.6'' \times \frac{1\ FT}{12''}$$

$$13.1\ ft \overset{?}{\leq} 37.3\ ft$$

$$13.1\ ft < 37.3\ ft$$

NPSH requirement met

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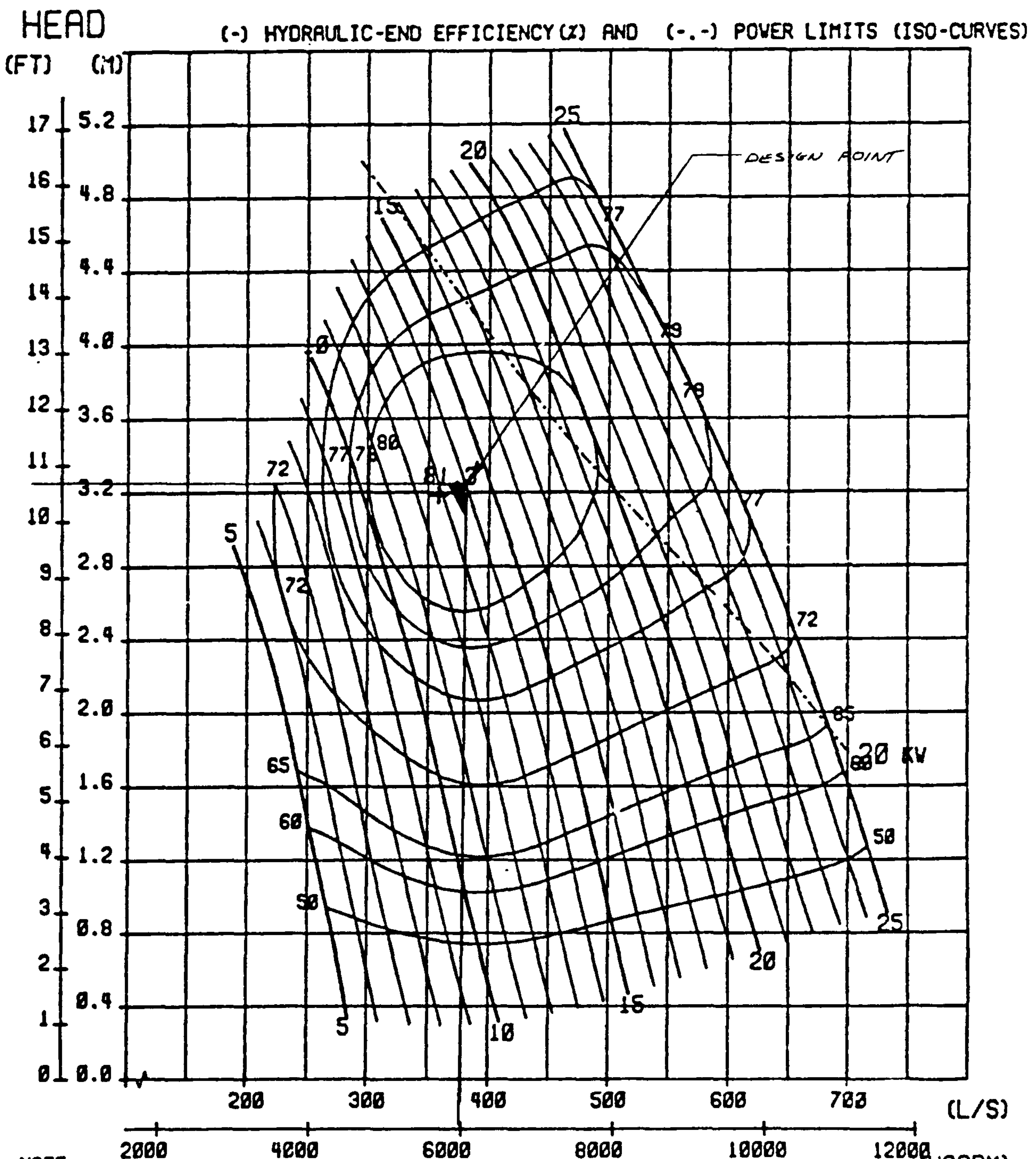
FLYGT

PERFORMANCE CURVE

7050

DATE 1984-06-05	ISSUE 3	FREQ 60 HZ	NOMINAL HYDRAULIC-END SPEED 700 RPM			CURVE NO 63-700B4
IMPELLER/HUB DIAMETER 460/260 MM	TYPE OF BLADES B			NO. OF BLADES 4		AVAILABLE BLADE ANGLES EVERY DEG. FROM 5 TO 25 DEG
MOTOR	POLES	SHAFT POWER	GEARTYPE	GEAR RATIO	GEAR EFFICIENCY (1/1-3/4 LOAD)	RATED SPEED
35-24-1	10	20.0 KW				700 RPM
35-28-1	10	33				700
40-30-1	10	45				695



NOTE:
CURVES ARE BASED ON NOMINAL CONSTANT HYDRAULIC-END SPEED
AND SHOW PERFORMANCE WITH CLEAR WATER.
ALL HYDRAULIC LOSSES UP TO 500 MM. ABOVE THE PUMP/MOTOR TOP ARE INCLUDED

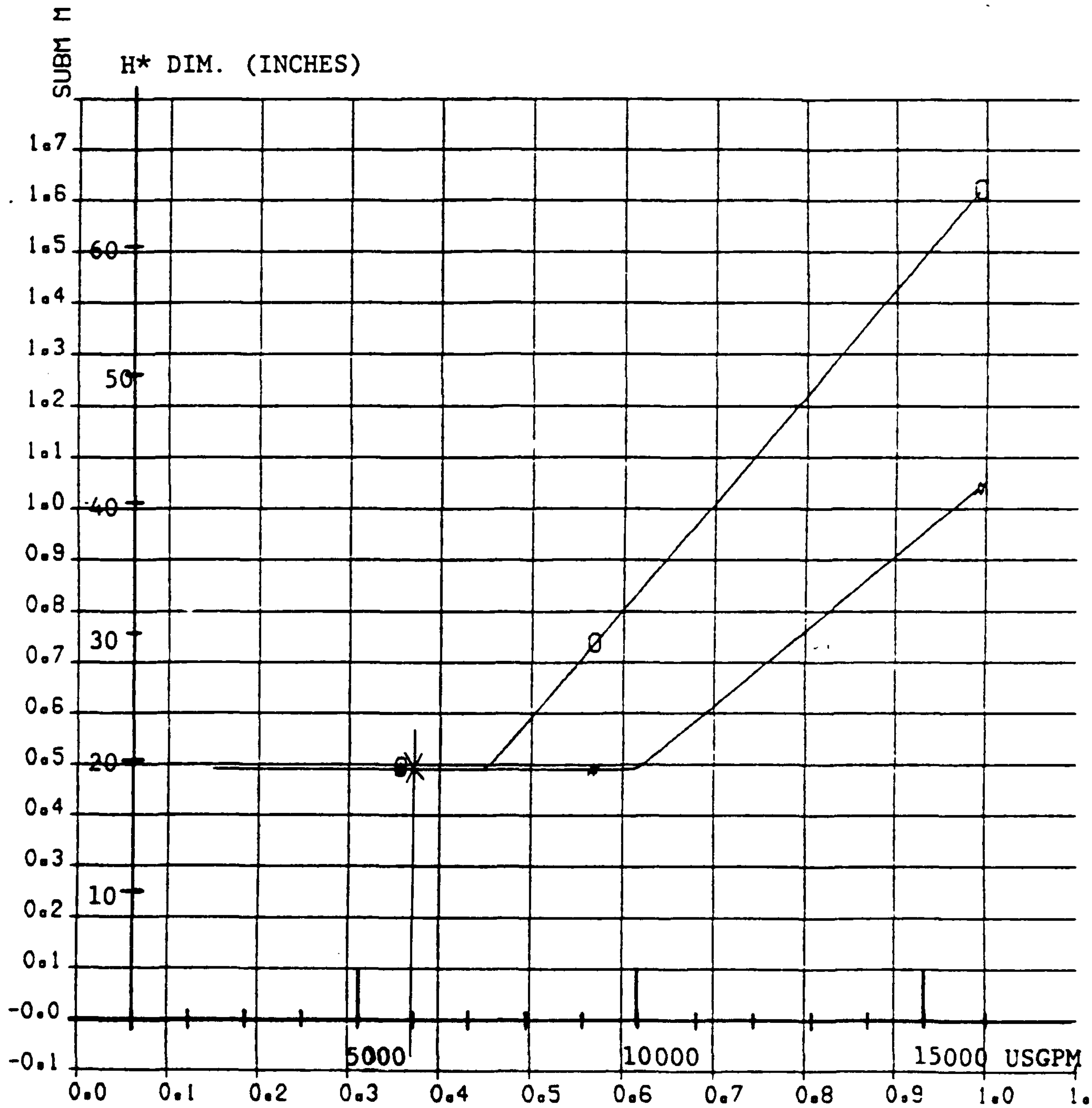
PLATE N-10

FLYGT SYSTEM AND APPLICATION ENGINEERING

DIAGRAM: SUBMERGENCE REQUIREMENTS FOR PL 7045/50	ISSUE: 2	DATE: 84-05-23

REQUIRED SUBMERGENCE FOR SUMP DESIGN ACCORDING TO FLYGT TYPE "A", "B".

REQUIRED SUBMERGENCE TO PREVENT VORTEXING WHICH WOULD AFFECT THE PERFORMANCE OF THE PUMP. IN SOME INSTANCES ADDITIONAL SUBMERGENCE MAY BE REQUIRED BECAUSE OF NPSH REQUIREMENTS.



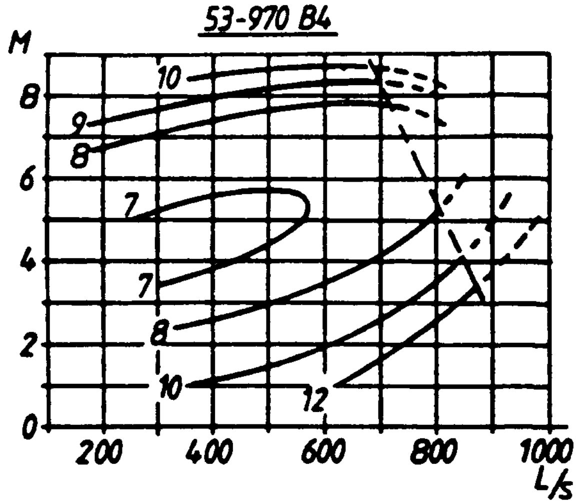
O:CONTINOUS OPERATION

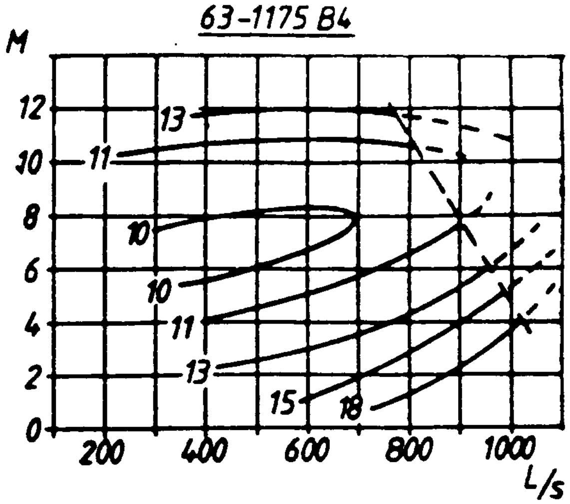
*:MAX 500 OPERATING HOURS/YEAR

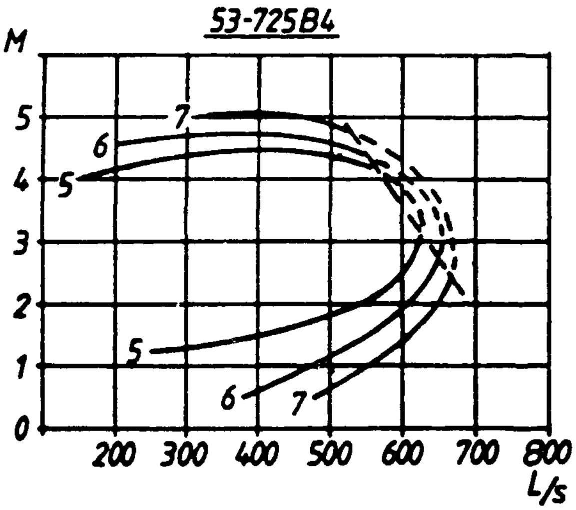
PLATE N-11

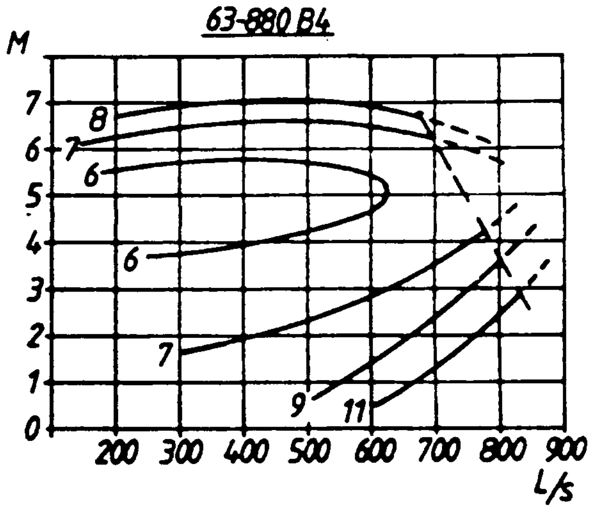
FLYGT	DATE 831006 / ISSUE 2	NPSH CURVES	7050

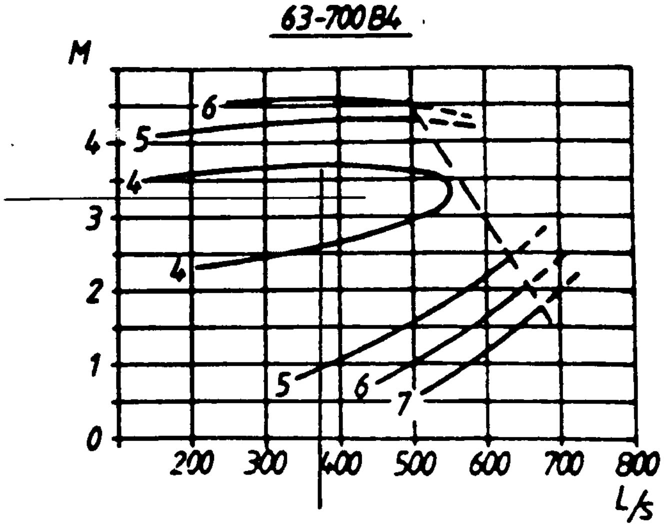
NPSH$_{RE}$ VALUES IN M H_2O











THE NPSH VALUES ARE RELATED TO THE INLET FLANGE.
ALL NPSH LIMIT CURVES ARE VALID FOR OPERATION WITHOUT LOSS IN PERFORMANCE AND NO REDUCTION ON LIFE TIME.

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III Annual Energy Costs for Pumping

Central Illinois Light Company (CILCO) General Service Rate 13 applied for energy costs. Based on 1/1/89 Rates, which apply to Commercial, institutional Municipal, or Industrial customer using firm service for all purposes.

- Customer Charge: \$ 8.37/Month every month

- Capacity Charge:

	Summer	Winter
Capacity Charge	\$ 3.32 per kW of Billing Demand	\$ 1.87 per kW of Billing Demand
Energy Charge	6.40¢ per kWH for the first 200 kWH per kW of Billing Demand	5.43¢ per kWH for the first 200 kWH per kW of Billing Demand
	3.18¢ per kWH for over 200 kWH per kW of Billing Demand	2.64¢ per kWH for over 200 kWH per kW of Billing Demand
	Jun 1 – Sept 30	Oct 1 – May 31

KW Billing Demand (D): The Billing demand for each month shall be 100% of the highest maximum demand (kW) created in the summer billing months of June–Sept during the most recent 12 month period, including the current billing month

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winter :

1st 0- 200(D) KWH --(D x 1.87 $) + (KWH x 5.43 ¢) + (Cust charge)

over 200(D) KWH -- (KWH x 2.64 ¢)

Summer :

1st 0-200 (D) KWH -- (D x 3.32 $) + (KWH x 6.4 ¢) + (Cust Charge)

over 200(D) KW -- (KWH x 3.18 ¢)

Monthly operating Breakdown

D = 17.4 KW From II.2, and will not vary since pumping is required during summer billing period.

Jan - 1 hr (0 fm)	Aug — 9.23 days (initial Fill)
Feb - "	Sept — 3.47 days (Makeup)
Mar - "	Oct — 2.70 days (Makeup)
April - "	Nov — 1.65 days (Makeup)
May - "	
Jun - "	
July - "	
Dec - "	

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MONTH	KWH	200XD(KW)	ENERGY $	TAX $ (5% State Utility)	Monthly $
JAN	17.4	3480	41.85	2.09	43.94
FEB	17.4	"	41.85	2.09	43.94
MAR	17.4	"	41.85	2.09	43.94
APR	17.4	"	41.85	2.09	43.94
MAY	17.4	"	41.85	2.09	43.94
JUN	17.4	"	67.25	3.36	70.61
JUL	17.4	"	67.25	3.36	70.61
AUG	3478.6	"	288.77	14.44	303.21
SEP	1449.1	"	158.88	7.94	166.82
OCT	1127.5	"	102.13	5.11	107.24
NOV	689.0	"	78.32	3.92	82.24
DEC	17.4	"	41.85	2.09	43.94

Annual TOTAL: 1064.4 $

say 1075 $/year

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Subject		Date
PEORIA LAKE PUMP STATION - ELECTRICAL		18 APR 90
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TRANSFORMER SIZING

CONNECTED LOAD - 30 HP, 460V, 3φ SUBMERSIBLE PUMP, $I_{FL(MAX)} \simeq 48A$

MOTOR SIZE	ABOVE GROUND MOTOR VOLTAGE 230V	460V	FACTOR	SUBMERSIBLE PUMP MOTOR "MAX. AMPS" 230V	460V
10 HP, 3φ	28A	14A	1.22	36A	18A
15 HP, 3φ	42A	21A	1.24	51A	26A
30 HP, 3φ	80A	40A	1.20*	96A*	48A*

$$kW = \frac{V \times I_{FL} \times PF \times \sqrt{3}}{1000}$$

$$kW = \frac{480 \times 48 \times 0.90 \times 1.732}{1000} = 35.9$$

TOTAL CONNECTED LOAD = 35.9 KW + 10% FUTURE CAPACITY = 39.5 KW

KVA = 39.5 KW / PF = 39.5/.9 = 43.9

RECOMMEND: 50KVA TRANSFORMER

* ESTIMATED, OTHER VALUES FROM NEC - TABLE 430-150 AND R.E. RONK ELECTRICAL INDUSTRIES

Subject PEORIA LAKE PUMP STATION - ELECTRICAL		Date 18 APR 90
Computed by CJA	Checked by [signature]	Sheet 17 of 23

<u>1ϕ CONDUCTORS SUPPLYING THE PHASE CONVERTER</u> (NEC 430-22(b))

$$I = \frac{V_{OUT}\ \text{CONVERTER}}{V_{IN}\ \text{CONVERTER}} \times I_{LOAD\ 3\phi}$$

$$I_{3\phi} = \frac{43.9\ \text{KVA} \times 1000}{\sqrt{3} \times 480} = 52.8\ \text{A}$$

$$I_{COND.\ 1\phi} = \frac{480}{240} \times 52.8 = 105.6\ \text{A}$$

\# 3/0 CU - 200 A (NEC - TABLE 310-16)

GROUNDING CONDUCTOR - #4 CU (NEC - TABLE 250-94)

I_{FL} FOR 50KVA TRANSFORMER - 208 A

<u>RECOMMEND</u>: 2 - # 3/0 CU, 1 - # 4 CU GROUND

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Subject PEORIA LAKE PUMP STATION - ELECTRICAL		Date 18 APR [illegible]
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DISCONNECT SWITCH AND FUSE SIZING

CONDUCTOR - #3/0 CU (200A)

$$I_{FL(1\phi)} = \frac{KVA \times 1000}{VOLT} = \frac{43.9 \times 1000}{240}$$

$$I_{FL(1\phi)} = 182.9\,A$$

RECOMMEND: 200A, 240VAC, 30 HP, 2 POLE SWITCH FUSED @ 175A (LAG TYPE)

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Subject PEORIA LAKE PUMP STATION - ELECTRICAL		Date 12 APR 90
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PERCENT VOLTAGE DROP (% V_D)

$$\% V_D = \frac{I_{FL} \times L \times \sqrt{3} \times \Omega}{V \times 1000} \times 100$$

Ω = DC RESISTANCE - OHM/1000 FEET

L = ONE WAY LENGTH

L = 20' + 20' + 10' = 50'

Ω = 0.0766 FOR # 3/0 CU (NEC - TABLE 8)

Ω = 0.302 FOR # 4 CU

$$\% V_D = \frac{48 \times 10' \times 0.0766}{240 \times 1000} \times 100$$

% V_D = 0.015 - FROM TRANSFORMER TO CONVERTER

$$\% V_D = \frac{48 \times 50' \times \sqrt{3} \times 0.302}{480 \times 1000} \times 100$$

% V_D = 0.267 - FROM CONVERTER TO PUMP

TOTAL % V_D = 0.015 + 0.267 = 0.22 : WELL BELOW 5% FOR MOTORS (NEC 215-2 (b))

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Subject		Date
PEORIA LAKE PUMP STATION - ELECTRICAL		[illegible]
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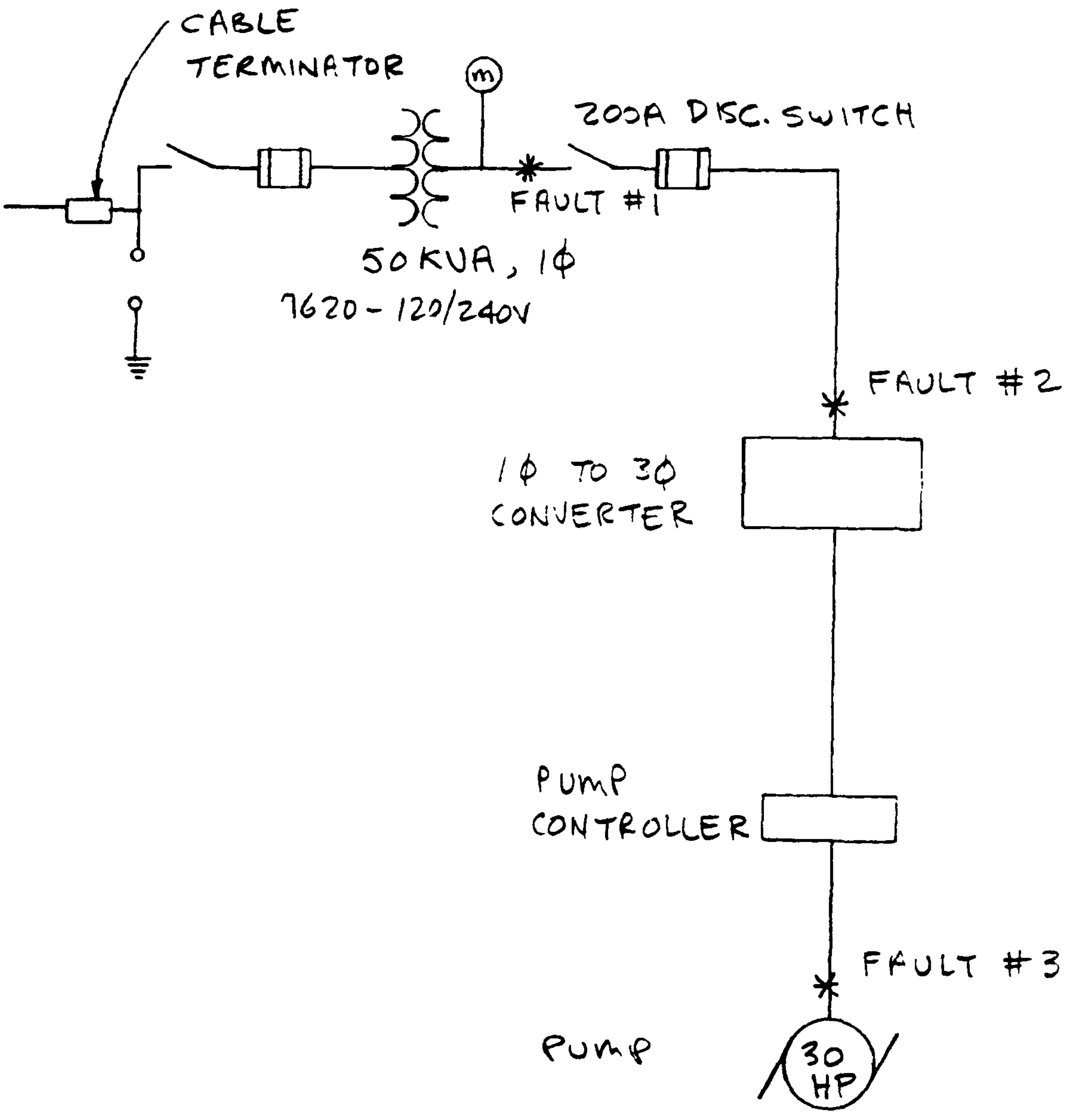
SHORT-CIRCUIT ANALYSIS *



PARTIAL ONE-LINE DIAGRAM

* ELECTRICAL PROTECTION HANDBOOK
McGRAW-EDISON BUSS - BULLETIN SPD84

Subject: PEORIA LAKE PUMP STATION - ELECTRICAL		Date: 18 APR 90
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SHORT-CIRCUIT CALCULATIONS

ASSUMPTIONS: INFINITE BUS ON TRANSFORMER PRIMARY, 100% MOTOR LOAD AT TRANSFORMER SECONDARY, %Z = 1.7

$$I_{FL} = \frac{KVA \times 1000}{E_{LL}} = \frac{50 \times 1000}{240} = 208\ A$$

$$\text{MULTIPLIER} = \frac{100}{\text{TRANSF. } \%Z} = \frac{100}{1.7} = 58.8$$

$$I_{SCA} = \text{TRANSF}_{FL} \times \text{MULTIPLIER} + \text{MOTOR LOAD} (96A \times 4)$$

$$= 208A \times 58.8 + 96 \times 4 = 12{,}614A \text{ @ TRANSF. SECONDARY}$$

$$f = \frac{2 \times L \times I}{C \times E_{LL}} = \frac{2 \times 10 \times 12{,}614}{10{,}400 \times 240} = 0.101$$

$$m = \frac{1}{1+f} = \frac{1}{1+0.101} = 0.908$$

$$* I_{SCA\,1\phi} = 12{,}614 \times 0.908 = 11{,}454A \text{ @ } \underline{\text{FAULT \#1}}$$

<u>RECOMMEND:</u> DEVICES HAVE INTERRUPTING CAPACITY OF 22,000 RMS. SYM.

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Subject PEORIA LAKE PUMP STATION - ELECTRICAL		Date 18 APR 90
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SHORT - CIRCUIT CALCULATIONS

3φ FAULT CURRENTS

$$I_{FL} = \frac{KVA \times 1000}{\sqrt{3} \times E_{LL}} = \frac{50 \times 1000}{1.732 \times 480} = 60.1A$$

$$\text{MULTIPLIER} = \frac{100}{\text{TRANSF. \%Z}} = \frac{100}{1.7} = 58.8$$

$$I_{SCA} = \text{TRANSF}_{FL} \times \text{MULTIPILER} + \text{MOTOR LOAD}$$

$$= 60.1 \times 58.8 + (40 \times 4)$$

$$I_{SCA\,3\phi} = 3{,}694A \text{ @ TRANSF. SECONDARY}$$

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SHORT-CIRCUIT CALCULATIONS

3Φ FAULT @ FAULT #2

$$f = \frac{\sqrt{3} \times L \times 3{,}694\,A}{10{,}400 \times 480} = \frac{1.732 \times 10 \times 3{,}694}{10{,}400 \times 480}$$

$$f = 0.0128$$

$$m = \frac{1}{1+f} = \frac{1}{1+0.0128} = 0.987$$

$$I_{SCA_{3\phi}} = 3{,}694\,A \times 0.987 = \underline{3646\,A}$$

3Φ FAULT @ FAULT #3

$$f = \frac{1.732 \times 50' \times 3{,}646\,A}{3{,}060 \times 480} = 0.215$$

$$m = \frac{1}{1+f} = \frac{1}{1+0.215} = 0.823$$

$$I_{SCA_{3\phi}} = 3{,}646 \times 0.823 = \underline{3{,}001\,A}$$